RAILWAY ENGINEERING AND MAINTENANCE OF WAY.

BRIDGES—BUILDINGS—CONTRACTING—SIGNALING—TRACK

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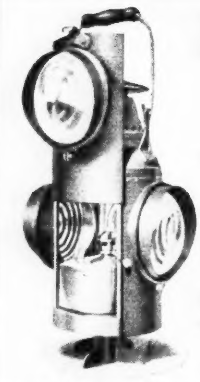

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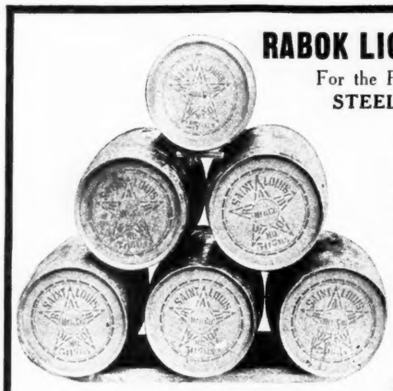

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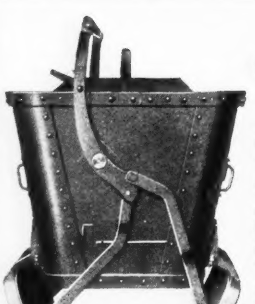

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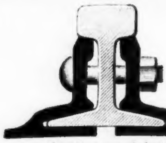

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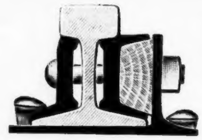

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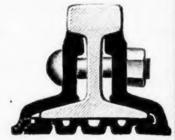

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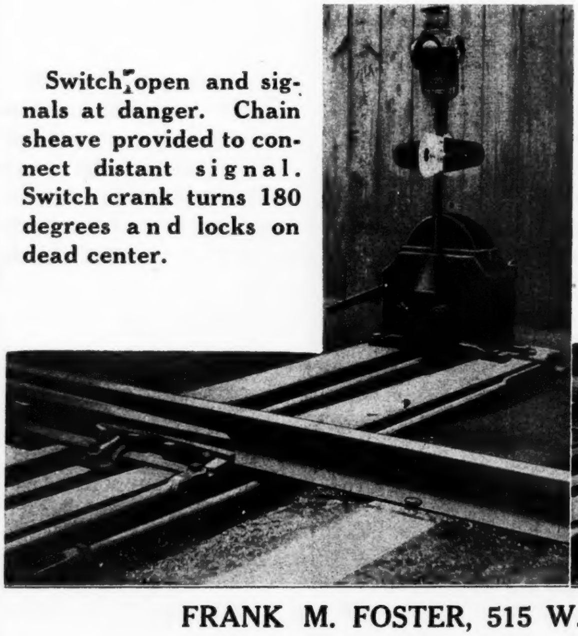

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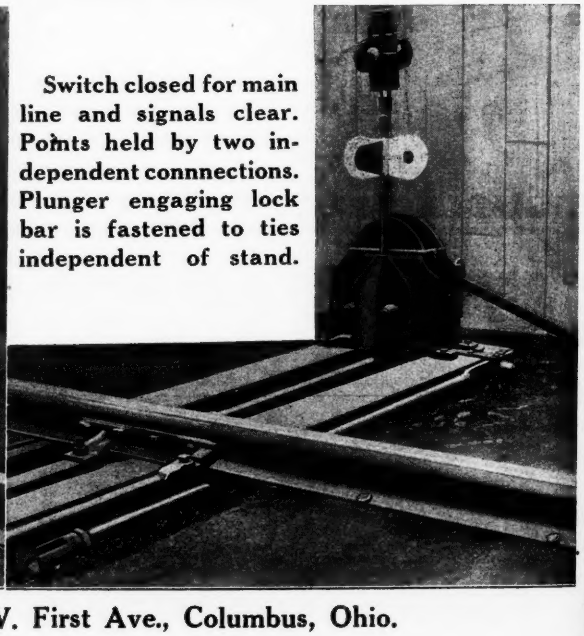

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BRIDGES-BUILDINGS-CONTRACTING-SIGNALING-TRACK

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Appreciation

We all like to hear ourselves praised. Especially do we enjoy the sensation when we are praised for doing good; when we are told that our good intentions have not miscarried but have hit the mark. The following letter speaks for itself and is worth more to us than the price of many subscriptions.

Editor Railway Engineering:

"Your valued journal came to hand yesterday, and after a very careful perusal of its pages, must admit that already I have profited more by reading the last three copies of your paper(the May issue was handed me by my roadmaster)than what one year's subscription price amounts to. Any trackman worthy of the name should be a subscriber and a constant reader of Ry. Eng. & M. of W. I myself, have for many years read other technical journals but it shall not prevent me from becoming a permanent subscriber to your paper, moreover I shall try to get all railroad men interested in your paper, as I believe in progress."

Texas. Foreman.

Reinforced Concrete

There is perhaps, no more live subject than this at present confronting the railways. The proper method of handling reinforcement, its proper location in the finished mass, its exact effects on the strength of the structure and methods of insuring that it is properly placed are all vital points which are discussed in a paper published in another column. The fact that the shifting of the reinforcement or any part of it by so much as one-half inch from its proper location may, and probably will, render useless all the calculations of the designer is not appreciated as much as it should be. Concrete is so easily handled that there is a tendency to employ unskilled labor and inexperienced supervision in the construction of reinforced structures. Nothing could be more foolish or uneconomical. As in other structural work, first-class results are obtained only by the use of high grade labor and expert supervision.

Treated Ties

We publish elsewhere an article on treated ties, together with the discussion provoked thereby. Perhaps many may feel that the merits of such ties have been sufficiently dinned into the ears of railroad men, but it is safe to say that there are yet many who do not appreciate fully the benefits derived from preservative treatment and still a greater number whose ideas are somewhat vague as to the methods of treatment and the reasons therefor. The article in question goes into these matters thoroughly and is a valuable contribution to the literature on the subject.

Education

The Chicago Signal Club, whose birth is mentioned in another column, should be an instrument of much good in the profession of railroad signaling in and about Chicago. The informality of its organization is one of its strongest points. It is organized for the mutual exchange of ideas among those engaged in the profession, there is no fixed membership, all interested being welcome to come to the meetings, and there are no dues. Similar organizations have sprung up in various parts of the country from time to time but have usually drifted on the rocks of formality and been wrecked. We hope no such misfortune will overtake the present club and that its example will be followed elsewhere not only among signal men but in other departments of railroading. Such clubs can be made of great value if properly handled. As we have said before, there is nothing that will compare in educational value with knowing what the other man is doing. That is the reason why we are publishing "Railway Signal Standards" and the personal views and experiences of roadway men.

Conventions

In October the Railway Signal Association and the American Railway Bridge and Building Association hold their annual conventions. We will cover these with two special de luxe editions, one in October containing portraits of prominent members of both associations together with pertinent matter and another in November containing full reports of the conventions. Do not fail to secure copies.

Notes on Concrete Construction

By Robert A. Cummings*

Someone has said that there is no parallel in industrial progress equal to that of the rapid development of the cement industry throughout the world. Engineers and technical authorities have scrutinized the subject from every angle resulting in its acceptance as a structural material.

Numerous tests have been conducted and theoretical deductions formulated for use in designing structures. While some are tentative, the straight line formulae for beams have been almost universally adopted. Yet, Engineers in general have largely neglected to prepare their designs to meet the practical conditions facing the constructor. It is to this point that I now invite your attention.

For construction purposes, concrete may be classified as plain, reinforced and structural. The application of plain concrete is frequently limited to gravity walls, piers, foundations, dams and similar bulk or mass work; whereas the term "reinforced concrete" has been applied to structures where any kind of metal reinforcement is embedded. This expression has been used indiscriminately. It has been made to cover plain concrete used for fireproofing or protection, etc. I believe that the expression does not sufficiently indicate the nature of concrete when applied to articulated structures. Therefore eight or nine years ago during the discussion of a suitable name for the new material, I adopted and have since used the term "structural concrete." It is more definite and descriptive of its use. The term has since been adopted by at least one regularly published periodical. In the use of structural concrete, the metal should be distributed in small sections so that every pound is utilized in strengthening the concrete in compression as well as in tension.

†Proceedings, Engineers' Society of Western Pennsylvania, 1904, Vol. 20, p. 577.

The interdependent relation between construction and design is as important in structural concrete as in any other departmen of engineering. One can readily understand the crudeness of all our first efforts in any direction. But the amateur is very much in evidence in the field of structural concrete and seems thoroughly entrenched. Yet there is great latitude for individual variation and judgment in the design and use of this material. An engineer has been described as "A man who can accomplish with one dollar that which any one can do with two dollars." Now my earnest hope is that we may avoid the reversal of this description. But, if we are to accomplish the best results, we must judiciously balance the composite parts of our problem. We cannot do this skillfully without sufficient knowledge properly to interpret the available data and the limitations of formulae. This is not all. Practical experience or knowledge as a constructor is equally necessary. If the economies of the materials as shown by our calculations are to be attained, it is just as important that they be combined with the practical conditions governing construction. These cannot fully, nor properly, be interpreted without intimate knowledge and experience in the methods of the field and a liberal endowment of that discriminating part of human nature frequently described as common sense.

An engineer would not venture to design an engine or a steel bridge without shop experience or full knowledge of the practical limitations in construction, so that it may be said with the same emphasis that his work in structural concrete should be governed by similar information. Absence of this requisite is partly accountable for the variations met.

The present age is noted for the quantity of books produced rather than the quality of the literature. This is particularly true of technical publications relating to concrete. For the most part they are made up of compilations or repeated data variously expressed by authors without practical experience. Further, these books have been a prolific source of confusion to the inexperienced practitioner. Consequently, he has become an easy victim to the shrewd salesman presenting the "talking points" of a variety of wings, knobs, twists, etc., given to the steel rods in order to find a market for them.

Only comparatively small structures are built truly monolithic because of the limitations of the amount of concrete that can be placed continuously. Yet the ordinary concrete building is considered monolithic on account of the intimate connection between successive day's work. Local or municipal regulations usually apply to monolithic work and govern the height of buildings and the permissible stresses to be used for materials, yet frequently fail to mention methods of execution or results to be secured.

The economical advantages of continuity in monolithic beams and slabs is dependent upon construction methods. The design should be governed by the amount of concrete that can be placed in a given work-period, or suitable provision be made for bonding the construction mechanically by steel rods embedded in the concrete made during both working-periods.

The shrinkage of monolithic concrete has caused much necessary as well as much unnecessary anxiety. Shrinkage is largely attributable to the cement, but the amount of cement in the mixture and methods used in mixing and subsequent exposure have much influence. Shrinkage may be resisted by embedded metal rods. I well remember an experience of eight years ago when testing some concrete beams 1:2½:5 gravel concrete 10 by 18 in. by 16 ft. long reinforced in the bottom only. Some of these beams showed cracks near the center of the top side the next morning after being made. The extreme ends had raised from the sill of the form as much as one-quarter of an inch. The cracks may be explained by the shrinkage of the concrete at the top of the beam while setting, thus raising of the ends of the beams, until the stress due to the weight of the raised part of the beam was in excess of the tensile strength of its concrete when the beams cracked at the weakest point.

Just as construction methods are related to design so they can be modified to suit the particular type of structure. Hence the unit concrete member has been made independently and erected in position much in the same manner as structural steel is erected. A reason is not quite clear why this method has not come into more general use, except perhaps, that it is neither patentable nor salable, so it has been let alone to demonstrate its own merit in due time. In its present development on account of numerous joints it should be limited to one-story buildings, such as round-houses, car barns, factories, etc.

The method is capable of combining most of the economics of design and construction. A great advantage is that the concrete is made and deposited in moulds at the ground level where men work more efficiently than from a high scaffold. The cost of forms is a minimum as less lumber is required because the forms are used more frequently with greater salvage. Again, the steel can be placed accurately with ease and at small cost, particularly when made at the shop in fabricated units, tagged and shipped to the work ready for placing in the molds. The cost of such steel is reduced to the minimum for placing. The design is also improved by eliminating uncertain assumptions used for continuity in girders and slabs. All members being simply supported.

Against these advantages one must offset the difficulty of join-

*Consulting Engineer, Pittsburg. Read before the Engineering Society of Western Pennsylvania.

ing the unit members together over columns. The old concrete of the beams does not readily unite with new concrete, so that special provision is required at the joints to unite the members into a rigid structure.

For the purpose of comparison, reinforcement is a phase of the subject which I approach with some trepidation, not only because I have long been identified with a particular method, but do not wish to have my remarks misapplied. Mention has been made of the possible variation in the disposition of steel in the concrete by different designers in their laudable attempt to secure the most economical results. This has led up to a few individual developments characterized as "systems." There has been much abuse of the word "system" in applying it to a variety of roughened rods. Yet there still survive by intrinsic merit certain features of the earlier methods. In a general way these methods may be divided into two classes—"loose rod methods" and "fabricated unit methods."

"Loose rod methods" may be summarized as consisting of a great variety of plain or deformed rods used and placed individually. This method is by far the most generally employed and most popular with contractors. I regret to say it is even so with some engineers, possibly because it is believed that the cost of the steel reinforcement is represented by the raw material.

The question of securing accurate placing of the reinforcement is a matter of small concern to the average contractor, for in his mind his contract is fulfilled by the mere embedment of the specific tonnage of steel rods in the concrete. Where? That is the business of the engineer, is his offhand answer. The contractor will use the cheapest material he can obtain under the plans and specifications. You cannot blame him for taking a business advantage of the loopholes conveniently provided in the contract, when he has had to meet the stress of the competition of inexperienced or conscienceless bidders and owners. Besides, if loose rod systems are the accepted practice of specialist constructors, why should he not use similar methods? The lowest price is invariably the controlling factor in securing contracts and he can estimate the cost as closely as any one from indefinite or loose rod plans and specifications.

If the loose rod practice of the present time is here fairly represented, it behooves us to stop and reflect a moment and to ask ourselves whether or not a change for the better can be made. For instance, let us more fully consider the question of misplaced reinforcement. I have been told by the engineer having charge of the fire and loading tests conducted by the bureau of buildings of a large eastern city, that, of all the tests made of the different concrete systems during the past few years, in 90 per cent of them the reinforcement was misplaced. That is, when wrecking the building the rods were found in different positions from those shown by the plans for the test structure. These test houses cannot be called every-day examples of work; they were carefully built for a special purpose to pass a special test. If, therefore, the reinforcement is misplaced under such conditions, what may we expect from work done under ordinary contracts. If the testimony of my twelve years of practical experience is of any value, I would say that reinforcement cannot be held in position except by a mechanical fastening for each rod, or by using the rods fabricated into a system of units made ready for placing and held in position in the concrete. The units should be sufficiently heavy to avoid any tendency to float, due to displacement in the semi-liquid mass. I do not feel called upon to show examples of the difficulties mentioned. They can be easily found by any one who desires such demonstration. But is the point important enough for our serious attention? Except for necessary covering to protect the steel, the only criterion may be said to be the strength of the beam, yet the strength is not seriously affected by a horizontal or lateral misplacement of the individual rods, if the rods are straight from end to end. But, should the hydrostatic action of the semi-liquid concrete or the depositing, puddling and ramming raise the rods, which is the usual case, a very much less bending strength will result. A slight vertical raising of the rods on short spans might cause a reduction of 50 per cent in the bending strength of the beams. This is a matter of vital consequence to the strength of any structure and commands our notice.

There is another contributory point in this matter of misplacement of the reinforcement and this can best be illustrated by an example from practice. My firm was recently invited to submit a proposal for an eight-story concrete building about 100 ft. by 100 ft., according to detail plans and specifications prepared by a western firm of architects and engineers. The reinforcement was designed upon the "loose rod" method. The beam and girder steel being bent up at the third points of the span and the shear steel disposed as vertical loose stirrups carefully shown on the drawings at small horizontal distances apart varying by fractions of an inch. This building was of common type and dimensions and required approximately 142 tons of steel reinforcement. According to the plans there were over 18,000 loose stirrups, every one of which must be accurately placed by an ordinary laborer, and not only that, they must remain in position during the operation of the depositing of the plastic concrete. In addition to these stirrups there were over 25,000 other loose rods for which no guarantee had been provided for positioning, except the generous disposition of the contractor. It seems to me that the lack of restraint and the freedom from exacting work in the manufacture of the concrete and the placing of the reinforcement as at present in vogue accounts as much as anything else for its popularity. It is certain that grave results would have followed its abuse were it not for the one intrinsic merit, that, as designed, structures are frequently stronger than anticipated.

I cannot leave the subject of reinforcement without referring to the distribution of the steel in the concrete. Let us assume that our personal preferences are in favor of certain strength formulae, the symbols of which we are most familiar with. The result of our calculations show say, three square inches of steel required for tension in the center of the beam. Eliminating the uncertainty of bond stress by providing mechanical anchorage at the ends of the rods, shall we use one, two, three or four, or how many rods? The answer is not to be found by formulae: but, in the combination of experience and the lowest unit cost of materials.

The much discussed merits of deformed vs. plain rods may be summarized by the question: What is the best shape that will give the area of steel with the greatest bearing perimeter and permit a maximum amount of concrete to surround each rod within the fixed limits of an economical size of beam? An angular cross-section of rod will give less satisfactory results than a round one. Because, a square twisted rod will occupy a space in a beam equal to the diagonal of the square, and this is nearly one and one-half times the diameter of a round rod. All deformed rods of the same nominal diameter and area occupy a greater cross-sectional space than round rods.

In the case of 1 in. and larger square twisted rods that have to be heated in order to be bent, there is an objection to their use because the annealing, due to heating at the bend, reduces the high elastic limit which is the only advantage gained from use of this particular form of rod. This fact is usually lost sight of and the practical result in a structure in which this form of reinforcement is used is that a tension factor has been employed in the calculations of the reinforcement which is greater than is actually secured at all points in those rods which are bent hot. In such cases where negative bending moments occur at the bent portions of the rods, the discrepancy between the actual and the calculated strength is a matter worthy of serious consideration.

It might be well to bear in mind certain commercial conditions that are met with. Rods as received from the mill may vary 5 per cent or more from the nominal size. In fact, my experience indicates the necessity of strenuous protest, as I have rarely found rods delivered in the exact manner ordered, and this is particularly true of the exact number, size and length required.

The disposition of the mill is to ship the tonnage ordered. The accuracy of the shipment depends upon the counting by some mill laborer. This is a formidable objection to loose rod methods as used in the field. It might result in the substitution of sizes of those on hand for those that are required. Besides in loose rod methods a large number of rods are invariably left over on completion of the job. Frequently enough to pay for the differences in cost between a shop-made reinforcement and the loose rods. The actual labor cost of placing the loose rods in parts of the structure to be described later, was over six times greater than the cost of placing the rods in fabricated units. Again, one rarely receives the exact lengths ordered, as there are thousands of rods to shear to various lengths and this is done by cheap mill labor. Further, rods are handled by grappling devices in the mill while more or less hot, so that kinks are left in them and they are shipped in this manner to the job. Unless straightened at the shop these bends constitute objectionable features in the reinforcement.

In connection with the placing of reinforcement and holding it in position, the most frequent cause of misplacement is due to the bending up or curving of single rods as they then become in unstable equilibrium and will fall over on one side in order to reach a state of stable equilibrium. Such rods are loose stirrups, turned up, or hooked, slab and beam rods.

There is another practical point for consideration. That is, the general use of "floating rods." These rods may be described as "gentlemen of leisure": that is, they are without visible means of support. The uncertainty of their final location makes them of questionable value.

My firm recently estimated on a concrete structure, plans for which called for long span beams. The detailed drawings gave evidence of thorough preparation. Two ½-in. rods were shown along the top of the beam to be placed exactly 3 inches from the outer surface to the center of the rods. These rods were 50 feet long without support or attachment! The deflection of rods due to their own weight requires that their unsupported length be limited, in order to secure stiffness and a reasonable degree of immovability while the concrete is being placed. These are some of the objections to be mentioned in connection with loose rods. They can be largely avoided by using fabricated shop-made reinforcement.

I can perhaps better illustrate such fabricated unit methods by reference to my own practice during the past few years. To be adapted to all the conditions that are likely to arise in practical work, such methods must comply with the theoretical essentials of design and meet the demand of practical constructors. They must be flexible enough to meet the preference for any shape of plain or deformed rod, and the reinforcement must be rigidly held in position from the molds while the concrete is being deposited. Each rod must be separated from its neighbor and completely embedded in concrete. The rods must be so disposed that the full benefit of the steel may be utilized for tensional stresses. Whether deformed or otherwise the rods should be mechanically anchored at their ends in the concrete in compression to make certain that there will be no slipping of the reinforcement and the full strength of steel may be developed.

I believe that my looped truss girder complies with these conditions and has the practical merit of being a complete self-contained unit for each beam. It is shipped flat, so as to not become bent and to occupy a small space in transit. It may be described as consisting of rods shaped into rectangular frames and arranged in two rows. The upper row consisting of small tension rods that are curved up for the desired length at suitable points to form the shear members, the loops are thus anchored into the compression part of the concrete beam. The upper row is separated from the lower row by a small bar driven tight, through holes in flat band staples, the end of this bar being bent down the correct distance to support the steel from the forms.

My hooped columns have in addition to the necessary vertical steel, individual steel hoops attached to a vertical spacing member at uniform distances. These hoops may consist of flat or round steel. The flat steel hoops give about 5 per cent greater core area for same weight of steel. The whole reinforcement is held rigidly together and forms a cage-like unit. Published tests have shown this form of hooping to be very efficient.

Mention may also be made of my chair lock. This is used in connection with units for slab reinforcement. In the slab units the tension rods are formed into rectangular frames which are spaced side by side and fastened to the shrinkage cross rods by the chair lock. This chair lock also securely positions the rods by supporting them from the forms. It is easily placed by simply pinching the top with a pair of heavy pliers.

Under the stress of present day competition, it is not surprising that engineers have found difficulty in having their requirements for concrete complied with. But occasionally plans and specifications may conflict with the practical conditions and economics of construction. Further, it is not universally understood that the cost of concrete structures is largely dependent upon the relation of design to methods of construction. Yet I have observed that the difference in prices named by bidders may be directly attributed to vague, indefinite and uncertain clauses, or omissions, in specifications. Obviously, where an essential is clearly detailed, there can be but little chance for variation or misinterpretation, so that other things being equal, the lowest bidder becomes successful. Again, does not the owner profit by competition between parties estimating from precise and clear information? It follows then that business relations are improved and there is a greater public appreciation of technical efficiency.

Perhaps there is no essential more frequently omitted from the specifications than the required strength value for the manufactured concrete. Specifications are usually elaborated in great detail, covering physical and chemical properties of the cement, aggregates, proportioning, and preparation of the concrete. Would it not be desirable to insist upon securing a given strength value for the concrete within reasonable limits and leave the manufacture to an experienced contractor?

In the design of beams, the size is much affected by the assumption for strength value. The strength for a given size beam may be almost doubled by the extremes of the assumptions now in use. Of course, in the latter case there must be an increase in the quantity of steel to balance the increase in unit compressive stress used for the concrete. On the one hand, by the use of very low unit stress in the concrete, we may get a beam, the dead weight of which is out of all proportion to the duty it has to perform. It is very desirable, therefore, that we keep our unit stresses of concrete at such fixed values that an economical size beam will be produced. Then, again, it is not desirable to fix the unit stress in the concrete without reference to the use of the structural member. For instance, in T beams and slabs a higher unit stress is permissible than in simple supported beams. The safe unit stress in hooped concrete columns may be a thousand pounds per square inch, whereas plain concrete is used as low as three hundred pounds.

While it has been shown that the strength of concrete increases with the amount of cement, it must not be forgotten that the difficulties with shrinkage are also increased.

The practice of making structural concrete so fluid that it may be conveyed through pipes by gravity is reprehensible in the light of present knowledge of the loss of strength, separation of aggregates and escape of cement with surplus water, although the cost of depositing the concrete may be diminished by such methods.

On account of the extensive scope of the subject I have omitted any reference to the development of metal forms for concrete members; and to the necessary organization for carrying out economical methods of construction.

J. H. Cooper has been appointed a roadmaster of the St. Louis & San Francisco, with office at Birmingham, Ala., succeeding F. W. Farrow, resigned.

Seasoning and Preservative Treatment of Ties

It is not my intention to bring to your consideration an expedient for the preservation of our forests, nor to attempt to cover the broadening field of chemical preservation of timber; but to present to you a few of the questions now being asked by interested railroad men pertaining to the seasoning and preservative treatment of wooden cross-ties, and to answer them as well as I can from the standpoint of some practical experience.

Probably there is no other interest in this country today which can compare with the railroad as a timber consumer, and certainly there is none which is more directly and vitally concerned in seeing that a constant supply of timber is assured in the future. In 1908 the steam roads bought, according to a Forest Service statement, 10,565,925 treated ties, and in addition they treated at their own plants 12,590,643, making a total of 23,156,568 for the year, or 21.8 per cent of the total number purchased. Today there are upwards of seventy timber treating plants in this country. Many of them are either owned or their output contracted for by the railroads, and are engaged almost entirely in treating cross-ties.

It is estimated that the requirements for renewals alone amount to more than one hundred million ties annually, nearly one-half of which are oak, about one-quarter pine, and the balance fir, cedar, chestnut, cypress, tamarack, etc. Up to within a few years ago, nearly all of the ties used by the railroads were white oak and longleaf pine. They were obtained in large quantities, at a low cost, and combined strength with great durability. These woods are each year becoming more scarce, are rapidly advancing in cost, and as a result, the railroads are turning to the so-called inferior woods, such as the red and black oaks, lodgepole, shortleaf and other pines, and the maples, gum, hemlock, beech, etc., for their supplies. These are not nearly so durable as the former, especially when brought in contact with the ground, and therefore require some kind of treatment to prevent decay.

It has been proved beyond all doubt, that these inferior woods can be chemically treated so that their life will be prolonged several years, making them last as long, or even longer than the best white oak untreated. More than 56,000,000 gallons of creosote and nearly 19,000,000 pounds of zinc chloride were used in preserving timber in the United States in 1908, as well as small quantities of crude oil, corrosive sublimate, and other chemicals. Sixty-nine per cent of the creosote used was imported, and but thirty-one per cent obtained from domestic sources. Nearly three-fourths of the imported creosote came from England and Germany; some from Nova Scotia, and some from Scotland and Holland. The domestic creosote was obtained chiefly in New York, Philadelphia and other large cities. The zinc chloride was all obtained from domestic sources, according to the reports. Most of it was produced by a few large chemical companies.

For the best results, cross-ties, as well as other timber, should be seasoned before applying a preservative. This can be done naturally or artificially, and no doubt the former way is much to be preferred: in fact with some methods of treatment it is absolutely necessary. Woods vary considerably in their seasoning properties. The coniferous woods check and split slightly as compared to some of the broad-leaved woods. For this reason they may be piled in more open piles and seasoned more rapidly. Such woods as ash, elm, hickory and beech seem to have a great tendency to check in rapid seasoning, and these ties should be piled closer together, and the seasoning retarded to some extent. A good plan is to place "S" irons in the ends of these ties as fast as they give evidence of splitting.

The time of the year in which ties are cut is said to have considerable influence in proper seasoning. Ties cut during the fall and winter are preferred to those cut during the summer, and some roads specify that ties will be accepted only when cut between October and the following April.

Ties should be piled at the treating plant in such a manner as to expose the greatest surface to the free circulation of the air, as the object is to dry the wood, so that it may be in proper condition to take the treatment. Ties piled in open cribs season much more rapidly than when piled in solid cribs. This may be well illustrated by the following test made with green lodgepole pine ties:

Date of Weighing	Solid Pile (9x9)			Open Crib Pile (7x2)		
	Weight Per Tie	Loss Per Tie	Percent of Loss	Weight Per Tie	Loss Per Tie	Percent of Loss
	Pounds	Pounds		Pounds	Pounds	
June 9,	152.75			155.39		
June 30,	130.93	21.82	14.28	108.06	47.33	30.45
July 15,	114.77	37.98	24.86	99.30	56.09	36.09
Aug. 13,	104.24	48.51	31.75	95.71	59.68	38.46
Sept. 10,	101.33	51.42	33.66	93.44	61.95	39.86

A study of these results shows that in three weeks the loss in the open crib pile was more than twice as much as in the solid pile, or nearly as much as the solid pile lost in two months. At the end of three months there was a difference of more than 6 per cent in favor of the open pile.

It has been found that ties piled 7x1 or 8x1 season practically as quickly as those piled 7x2, and in addition there is the advantage of economy in space, and furthermore every other tier being on a slant, water is shed to some extent. Ties that have a great tendency to check and split should not only be piled close together, but should have the ends partially protected from the direct rays of the sun, by piling in such a way that the cross-tie above laps over the ends of the ones underneath.

There are a number of different processes, or methods, of treating timber. Nearly all of them employ heavy oil of coal tar (commonly called "creosote"), or chloride of zinc, either separately or in combination. Among the more prominent processes used in this country, may be mentioned the following:

Burnett ....Using Zinc Chloride.
Bethell ....Using Creosote.
Rueping ....Using Creosote.
Lowry ....Using Creosote.
Allardyce ....Using Zinc Chloride and Creosote.
Card ....Using Zinc Chloride and Creosote.
Non-Pressure or Open Tank.

The "Burnett," or as it is commonly called, the "Burnettizing" or straight zinc chloride process was introduced in 1838 by Sir William Burnett. Either seasoned or unseasoned timber may be treated, but with this, as well as nearly every other process,

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*From a paper read before the New York Railroad Club.

it is much better to have the timber thoroughly air seasoned. After the wood is prepared for treatment by air seasoning or steaming, a vacuum is usually created, then a water solution carrying from 2 per cent to 6 per cent of zinc chloride is introduced, filling the retort. A pressure pump is then used to pump in more solution until 100 to 150 pounds pressure is registered on the guage, and this pressure is maintained until the required absorption is obtained, after which the solution is withdrawn and the timber taken out.

It is generally the practice to use a solution of such strength, that after the wood has absorbed all that can be forced into it within a reasonable time, it will retain about one-half pound of pure zinc chloride to the cubic foot of timber. It is best to use ties treated with this process in comparatively dry climates, on account of the solubility of the zinc chloride, and the subsequent leaching of the zinc salts.

The "Bethell," or straight creosote process, was invented in 1838 by John Bethell. This consists of first creating a vacuum in the treating cylinder, or retort, followed by the introduction of creosote, and then applying a pressure to force the creosote into the wood.

The "Rueping" process was patented in September, 1902. Only thoroughly air-seasoned timber can be treated. The wood is first subjected to an air pressure of about five atmospheres, so that all the cells and cavities are filled with compressed air after which, while maintaining the air pressure, the impregnating liquid, under a still higher pressure is introduced into the receptacle in which the material treated is placed. The air in the receptacle is allowed to escape. The material, now being entirely covered with the liquid, pressure can be raised with a pump, thereby forcing it into the wood. After a certain quantity is absorbed, the pressure is released, and the liquid discharged. The air, first forced into the wood cells, expands, thereby expelling the surplus oil, and this may be aided by a final vacuum. It is claimed that about 50 per cent of the oil can be regained by this method, and enough is left in the wood to insure it against decay during the mechanical life of the tie.

The "Lowry" process was patented September, 1906. It consists of placing the ties in a retort or cylinder and closing the doors air tight. The retort is then filled with creosote and pressure applied by forcing more oil in with a pump. The pressure is continued until the wood takes up a certain amount of oil, after which the free oil is quickly withdrawn. The next step is to produce a quick and high vacuum, the object being to regain a portion of the oil which was first injected into the wood, thus leaving the cell walls painted with the preservative, but the cells themselves practically empty.

It is claimed that a red oak tie requires about 4½ gallons of oil, and a pine tie about seven gallons to saturate it completely, and after a quick and high vacuum, representing about 25 to 27 inches of mercury, is maintained for from one and one-half to two hours, the quantity of oil left will be about two and one-half gallons in either case, all of which is thoroughly absorbed and taken up by the fibres. This means that in the case of oak ties, about 44 per cent is regained, and in the case of pine ties about 64 per cent is regained by the final vacuum. Some tests were made to show how much oil could be regained in actual practice, and the results will be shown later.

With the "Allardyce" process, both zinc chloride and creosote are used. Ties are first impregnated with zinc chloride, as in the Burnettizing process, after which creosote is introduced, and a pressure applied, until two or three pounds per cubic foot are injected. The object of the after treatment of creosote is to prevent the leaching of the zinc salts.

The "Card" process was patented in March, 1906. This, as well as the Allardyce, employs both zinc chloride and creosote, but both in one solution. The creosote is mixed with the zinc chloride, in varying proportions, and is kept thoroughly mixed, under pressure, by a centrifugal pump. It not only has the advantage of a one movement process, but the oil is probably carried farther into the wood, and more evenly distributed, the light soluble oils going into the heartwood with the water solution of zinc. Either seasoned or unseasoned wood may be treated.

The non-pressure process is coming more and more into use, and, as stated by Mr. W. F. Sherfesee, of the U. S. Forest Service, it provides a cheap and efficient method of treating certain of the more porous classes of timber in isolated locations, and is well suited to the small users to whom the expense of the commercial pressure plants is prohibitive. I will not take the time to describe the process, but refer those interested in it to the officials of the Forest Service who have made numerous experiments, and who doubtless will be glad to answer any questions regarding it.*

Some woods naturally absorb the preservative readily, while others are more or less refractory. Among the easily treated woods may be mentioned certain pines, soft maple, elm, and birch. The gums, poplar, sycamore, etc., require a somewhat longer time to get a good penetration, while the oaks, hickory, beech, hemlock and tamarack, are usually more or less difficult to treat, although when thoroughly seasoned, and with some processes, a very good treatment can be obtained.

For the best results, each kind of wood should be treated by itself. This is not always practicable, in which case, they may be grouped into two or more classes. On the Burlington, at the present time, three classes are used. Class "A" includes all wood absorbing less than 22 per cent in volume; class "B" from 23 per cent to 30 per cent and class "C" more than 30 per cent. Each class requires a different strength of solution, when zinc chloride, or a combination of zinc chloride and creosote is used. This is necessary in order to leave a certain quantity of the preservatives in the wood after the treatment is completed.

The following table shows results obtained in treating sixteen different kinds of wood in one cylinder at the same time. Cypress absorbed the most and hickory the least. Another test would doubtless give slightly different results, but from numerous tests made, the one presented here gives a very good illustration of the relative ease with which these woods absorb the solution under exactly the same conditions.

COMPARATIVE TREATMENT OF 16 DIFFERENT KINDS OF WOOD WITH THE CARD PROCESS

(ALL GIVEN SAME TREATMENT IN ONE CHARGE)

C. B. & Q. TIMBER PRESERVING PLANT, GALESBURG, ILL

Kind of Wood	No. of Ties Treated.	Ave. Weight Per Cub. Ft.		Increase		Absorption Per Cub. Ft.	
		Before treatment.	After treatment.	Weig't per cent.	Vol. per cent.	Lbs. of zinc clo'r'd.	Lbs. of creosote.
Cypress	37	34.54	64.62	87.63	47.89	.981	5.75
Red Elm	40	42.31	69.58	64.13	43.02	.882	5.16
Birch	43	38.33	62.33	62.61	37.92	.778	4.56
White Elm	44	42.17	65.67	54.55	36.33	.761	4.47
Soft Maple	46	35.87	58.67	64.49	36.33	.785	4.37
Cottonwood	31	28.20	49.77	76.47	34.12	.699	4.10
Tupelo Gum	43	35.50	55.33	55.87	31.38	.643	3.77
Shortleaf Pine	47	37.83	55.67	47.13	28.22	.578	3.39
Poplar	45	34.67	52.00	50.00	27.43	.562	3.29
Sweet Gum	49	42.50	59.17	39.22	26.37	.540	3.17
Beech	48	47.00	61.50	30.85	22.94	.470	2.76
Red Oak	41	45.50	57.33	28.84	20.31	.383	2.25
Tamarack]	38	39.00	50.33	30.73	18.96	.388	2.28
Hemlock	33	30.17	41.83	38.70	18.46	.378	2.22
Hard Maple	38	46.17	56.50	22.38	16.35	.335	1.96
Hickory	42	53.17	62.33	17.24	14.50	.297	1.74
Average		39.56	57.60	68.68	28.53	.584	3.43

When ties are thoroughly air seasoned, steaming is generally unnecessary, and in fact may be detrimental. When green, containing considerable sap or pitch, or when completely water

*Note:—Since the above was written, the Forest Service has issued Bulletin No. 78, entitled "Wood Preservation in the United States." This Bulletin was written by Mr. Sherfesee, and he goes more into detail in describing the different processes.

soaked from lying in the water a long time, it is often necessary to resort to artificial seasoning to get a good absorption of the preservative. This is usually obtained by subjecting the timber to a steaming process, at temperatures varying from 10 to 20 pounds of steam pressure for ties or smaller timber, to 30 or more pounds for piling and large dimension material. The duration of steaming may extend over a period of from two to five or more hours, depending entirely upon the condition of the wood. The claim made for the steaming operation is that certain elements contained in the wood are more or less liquified and are expelled by the heat generated in the cells, thereby increasing the permeability of the cell walls.

In the table below is shown the results of a test made at one of the Burlington plants in the steaming of dry and green lodgepole pine ties.

TABLE "A"

LODGEPOLE PINE (DRY)

Run No.	Seasoned	Weight Per Tie in Pounds			
		Before Treating	After Steaming	After Vacuum	After Treating
369	12 weeks	114.00	120.00	118.00	143.47
373	12 "	110.47	115.73	114.13	147.66
378	12 "	111.93	116.07	114.53	151.00
382	12 "	114.00	119.60	117.40	156.73
386	12 "	115.20	121.33	118.87	150.66
Average per cent gain over untreated ties		113.12	118.55 4.80	116.59 3.07	149.90 32.51

LODGEPOLE PINE (GREEN)

Run No.	Seasoned	Weight per Tie in Pounds			
		Before Treating	After Steaming	After Vacuum	After Treating
369	Green	163.90	166.00	163.33	197.66
373	"	148.93	150.47	148.06	185.20
378	"	158.66	158.73	157.07	193.13
382	"	163.66	163.87	160.87	203.13
386	"	166.86	165.87	162.40	201.13
Average		160.26	161.19	158.35	196.05
Per cent gain over untreated tie.			.58		22.33
Per cent. loss over untreated tie.				1.19	

From this table it will be seen that the steaming of pine resulted in a gain of 4.8 per cent after the steaming, of which 1.73 per cent was lost after the vacuum, or in other words after the steaming and vacuum operation, the timber had increased in weight 3.07 per cent and this increase consisted of moisture. In the case of the green timber, the increase after steaming was .58 per cent while after the vacuum there was a loss of 1.19 per cent.

This test, and many others along the same line, shows that when dry timber is steamed, the weight of the wood is really increased by moisture and with green timber there is a slight loss after steaming and vacuum. There is perhaps no question but that a preliminary treatment with steam does render green or unseasoned wood more permeable for a water solution treatment.

Many tests have been made to show the relative absorption of steamed versus non-steamed timber, and a study of the table below will lead to the following general conclusions: Thoroughly seasoned lodgepole pine treated without steam gained 80 per cent in weight, while with steam the gain was but 76 per cent. Thoroughly seasoned douglas fir treated without steam gained 42 per cent in weight, while the gain with steam was but 39 per cent. The reverse is true with unseasoned timber, as the results show.

By omitting the steaming process the time of treatment is greatly reduced and thereby a material saving in cost effected.

The following tables give a summary of a series of tests made to see what influence the steaming for various lengths of time has on seasoned and water soaked timbers. A number of tests were made in which the ties were steamed three and four hours, using steam pressures up to 60 pounds. In each case two ties only were used, therefore, this test cannot be considered conclusive.

TABLE "B"

(STEAMING VS. NON-STEAMING)

LODGEPOLE PINE

	With Steam			Without Steam		
	Season 10 weeks	Season 8 to 9 months	Season over 1 year	Season 10 weeks	Season 9 to 10 months	Season over 1 year
Average w'ght per tie before treat'g.	118.0	111.4	104.5	111.1	99.9	95.9
Av. weight per tie after treating.	183.0	186.4	184.0	162.5	150.9	172.7
Gain per tie	65.0	75.0	79.5	51.4	51.0	76.8
Per cent. of gain	55%	67%	76%	46%	51%	80%
Lbs. of dry zinc chloride absorbed per tie	1.98	2.28	2.42	1.54	1.53	2.31
Av. weight per tie before treating	114.2	108.7	101.5	116.7	97.5	103.3
Av. weight per tie after treating	148.3	149.7	141.2	148.8	135.3	146.4
Gain per tie	34.1	41.0	39.7	32.1	37.8	43.1
Per cent. of gain	29%	38%	39%	27%	38%	42 .%
Lbs. of dry zinc chloride absorbed per tie	1.27	1.53	1.48	1.22	1.44	1.64

SUMMARY OF SERIES NO. 2

LODGEPOLE PINE TIES

Run Number	9	10	11	12	13
Steaming, Hours	3	3	3	3	3
Steaming, guage pressure, pounds	**20**	**30**	**40**	**50**	**60**
Av. temperature of steam, Fah	261°	274°	279°	298°	308°
Vacuum, hours	1	1	1	1	1
Vacuum, inches	21	21	21	21	21
Solution at 100 lbs. pressure, hours	3	3	3	3	3
Av. temp., zinc chloride solution, Fah	145°	150°	146°	138°	145°
Strength of solution	.0305	.0302	.0307	.0308	.0306
Per cent. increase in weight per tie over original. (Seasoned)	50	55	60	68	82
Per cent. increase in weight per tie over original. (Water soaked)	11	20	19	18	22
Per cent. increase in weight per tie over vacuum. (Seasoned)	36	51	48	60	75
Per cent. increase in weight per tie over vacuum. (Water soaked)	24	29	28	30	32
Zinc chloride absorbed per cu. ft., lbs.	.311	.506	.502	.475	.666

RED FIR TIES

Run Number	14	15	16	17	18	19	20
Steaming, hours	None	4	4	4	4	4	4
Steaming, gauge pressure Pounds	"	**10**	**20**	**30**	**40**	**50**	**60**
Av. tem. of steam. Fah.	"	238°	258°	270°	282°	290°	299°
Vacuum, hours	1	1	1	1	1	1	1
Vacuum, inches	20	21	20	21	21	20	20
Solution at 100 lb. pressure, hours	4	4	4	4	4	4	4
Av. temp. of zinc chloride solution, Fah.	146°	145°	148°	145°	144°	141°	148°
Strength of Solution	.0352	.0351	.0355	.0354	.0350	.0358	.0356
Per cent. increase in wght per tie over orig. (seas.)	45	48	48	42	59	71	71
Per cent. increase in w'gh per tie over orig. (green)	20	30	33	37	36	60	51
Per cent. increase in wht. per tie over vac. (seas.)	..	42	45	37	50	67	..
Per cent. increase in wht. per tie over vac. (green)	..	30	37	33	34	57	..
Zinc chloride absorbed per cubic foot, pounds.	.378	.467	.502	.490	.615	.760	.753

A study of these results will show that the higher the steam pressure the greater will be the absorption of zinc chloride solution; however, excessive pressures should not be used, as the wood may be greatly weakened as will be shown later.

A series of tests were undertaken in a preliminary way to ascertain at what temperature of the solution the best penetration could be obtained. The following table shows the summary of results:

Run Number	21	22	23	24	25
Steaming, hours	3	3	3	3	3
Steaming, gauge pressure, pounds	30	30	30	30	30
Av. temperature of steam, Fah	270°	270°	270°	270°	270°
Vacuum, hours	1	1	1	1	1
Vacuum, inches	21	21	21	21	21
$ZnCl_2$ Solution, 100 lbs. pressure, hrs	3	3	3	3	3
Temperature of solution when introduced, (Fah.)	60°	80°	104°	126°	144°
Minimum temperature of solution during treatment. (Fah.)	60°	80°	100°	124°	144°
Max. temperature of solution during treatment. (Fah.)	90°	88°	108°	130°	150°
Temperature of solution when forced back (Fah.)	80°	84°	100°	124°	148°
Strength of solution	.0200	.0205	.0204	.0207	.0205
Per cent increase in weight per tie over original. (Seasoned)	60	59	91	85	100
Per cent. increase in weight per tie over original. (Green)	41	45	39	44	42
Per cent. increase in weight per tie over vacuum. (Seasoned)	55	55	86	80	90
Per cent. increase in weight per tie over vacuum. (Green)	42	47	39	44	39
Zinc chloride absorbed per cu. ft., lbs.	.315	.383	.402	.420	.413

The following is a summary of results obtained from a series of tests made at the Galesburg Timber Preserving plant, to determine the amount of creosote that can be recovered in the final vacuum, from different kinds of wood treated with the Lowry process; and also the amount of creosote that can be recovered from the dripping of the ties without a final vacuum from the same kinds of wood treated with the straight creosote process.

LOWRY PROCESS

Kind of Wood	Net Weight per Cubic Foot			Pounds Creosote Absorbed per Cubic Foot			Max. Gallons of Creosote Abs'd per Tie	Per cent. Creosote Regained After Vacuum
	Before Treating	After Treating	Gain	Total Absorption	Regained by Vacuum	Remaining After Treatment		
Red Oak	53.0	59.5	6.5	7.12	.65	6.47	2.49	9.09
" "	55.8	63.1	7.3	7.97	72	7.25	2.49	9.09
" "	44.9	54.6	9.7	10.39	.71	9.68	3.34	6.78
" "	44.0	54.3	10.3	11.01	72	10.29	3.68	6.46
Sh'rtlf. Pine	38.1	57.4	19.3	20.43	1.14	19.29	6.51	5.57
" "	32.5	51.7	19.2	21.69	2.41	19.28	6.83	11.11
" "	33.2	49.8	16.6	18.61	2.03	16.58	5.61	10.91
" "	32.2	49.9	17.7	20.39	2.70	17.69	6.50	13.26
Hemlock	36.5	51.4	14.9	16.51	1.65	14.86	5.20	10.02
"	32.0	46.5	14.5	16.02	1.54	14.48	4.70	9.64
Tamarack	33.1	46.5	13.4	15.08	1.63	13.45	5.25	10.80
"	35.9	50.9	15.0	16.58	1.63	14.95	5.28	9.87
Hard Maple	46.3	64.6	18.3	20.23	1.90	18.33	6.74	9.41
" "	46.4	65.8	19.4	21.90	2.51	19.39	6.93	11.46
Birch	33.1	53.2	20.4	22.92	2.73	20.19	6.94	11.93
"	34.9	54.9	20.0	22.02	2.06	19 96	6.67	9.35
								9.93

STRAIGHT CREOSOTE PROCESS

Kind of Wood	Net Weight per Cubic Foot			Pounds Creosote Absorbed per Cubic Foot			Max Gals. of Creosote Abs'd per Tie	Per cent Creosote Regained After Dripping
	Before Treating	After Treating	Gain	Total Absorption	Regained by Dripping	Remaining After Treatment		
Red Oak	46.9	57.4	10.5	11.09	56	10.53	3.58	5.06
" "	48.0	55.8	7.8	8.39	.58	7.81	2.61	6.96
" "	47.5	57.0	10.3	11.08	74	10.34	3.39	6.69
" "	49.3	60.6	11.3	12.33	1.01	11.32	4.14	8.22
Sh'tl'f Pine	36.8	55.8	19.0	21.09	2.06	19.03	6.38	9.77
" "	36.4	56.5	20.1	21.69	1.21	20.48	7.13	5.66
" "	37.5	52.6	15.1	16 09	1.02	15 07	5.18	6.34
" "	34 6	51 6	17.0	18.52	1.51	17.01	5.84	8.16
Hemlock	33.8	50.5	16.7	17.97	1.30	16.67	5.50	7.22
"	32.4	50.6	18.2	19.85	1.64	18.21	6.03	8.27
Tamarack	39.7	48.0	8.3	9.39	1.07	8.32	2.97	11.40
"	36.6	49.9	13.3	14.73	1.38	13.35	4.94	9.40
Hard Maple	48.2	68.7	20.5	22.53	1.95	20.58	7.87	8.65
" "	44.6	63.3	18.7	20.14	1.41	18.73	6.80	7.00
Birch	42.5	66.4	24.0	25.51	1.54	23.97	7.72	6.02
"	43.7	68.9	25.1	27.04	1.91	25.13	8.19	7.06
								7.54

The results of these tests agree with similar tests made by the Chicago Tie Preserving Co., and show that nearly as much creosote can be regained by allowing the ties to drip for two hours without a vacuum. The average amount regained after two hours dripping from all the ties tested was 7.54 per cent; 4.38 per cent of this amount was regained after 30 minutes; 6.00 per cent after 1 hour, and 7.04 per cent after 1½ hours, or in other words, more than 80 per cent of the total was regained in one hour.

In making these tests, the creosote in every case was introduced at 180 deg. F. Pressure varied from 125 to 175 pounds, according to kind of wood treated, and duration of pressure was from one to six hours, in every instance pumping to refusal.

Prof. Hatt, Civil Engineer, Forest Service, has made extensive tests on the effects of treatment of timber, and the following are his conclusions:

(1)—"A high degree of steaming is injurious to wood. The degree of steaming at which pronounced harm results will depend upon the quality of the wood, and its degree of seasoning, and upon the pressure (temperature) of steam and the duration of its application. For loblolly pine the limit of safety is certainly 30 pounds for four hours, or 20 pounds for six hours."

(2)—"The presence of zinc chloride will not weaken wood under static loading, although the indications are that the wood becomes brittle under impact."

(3)—"The presence of creosote will not weaken wood of itself. Since apparently it is present only in the openings of the cells, and does not get into the cell walls, its actions can only be to retard the seasoning of the wood."

The Forest Service Department says:

"In 1908 the steam and electric railroads of the United States bought 112,463,499 cross ties. Of this number 81.8 per cent were hewed and 18.2 per cent were sawed. Over 42 per cent of the total number of ties were oak, and nearly 88 per cent of these were hewed.

"About 95 per cent of the hewed ties and 91 per cent of the sawed ties were bought by the steam railroads. The steam railroads prefer hewed ties, owing largely to their lower cost and greater durability, and to the better surface they afford for the frequent or periodic tamping necessitated by heavy traffic. The average cost of sawed ties was two cents greater than that of hewed ties."

In 1905 the International Railway Congress addressed the managements of all American railways asking them to report the average length of life of sawed ties as compared with hewed ties of the same kind, and if there was any difference, to what they attributed it. The replies received showed that opinions were divided. Some said they knew of no difference, while others said that hewed ties lasted somewhat longer than sawed ties. The majority, however, reported in favor of the hewed ties, saying, that as a rule, they last about two to three years longer than sawed ties. One of the reasons given was that when ties are sawed, the fibres are cut across leaving a rough surface which absorbs water more readily than the clean cut surface formed when a tie is hewed.

This objection to the sawed tie is no doubt true to a greater or less extent when it is used untreated, and perhaps also when treated with a water soluble preservative, but when treated with creosote, which is insoluble in water, it would seem that this argument would not hold good, and that therefore, from a preservative standpoint the sawed tie should give as good results as the hewed tie.

One of the most frequent questions asked is "How long will a treated tie last?" Many points must be considered in attempting to answer such a question: as for instance, the kind of wood treated, process used, amount of preservatives injected, locality where tie is used, condition of road-bed, etc.

For comparison we should first want to know how long an untreated tie will last. Along the Burlington in Wyoming and South Dakota, an untreated pine or fir tie will give a general average life of six or seven years: while in Iowa, Illinois, Missouri, and Eastern Nebraska, the average life may not be more

than five years. A good white oak tie will last possibly nine or ten years.

Leaving white oak entirely out of the question, and considering only the inferior oaks and other short lived woods requiring treatment, it will no doubt be safe to say that the average life of untreated ties in the states named is six years, and that a good treatment costing between 15 and 30 cents per tie will easily double the life.

In certain sections of the South an untreated loblolly pine tie will not last a year. Prof. Alleman says he has seen Burnettized ties placed in Texas and after three years of service, removed on account of decay. Records kept on 5,000,000 ties on the Santa Fe prove that longleaf, shortleaf and loblolly pine ties, when properly treated with zinc chloride had a life of about ten and one-half years.

Out of a total of 1,929,855 ties treated with zinc chloride by the Chicago Tie Preserving Co. for the C. & E. I., 21,822 were removed for all causes, and only 12,678 removed account of decay after nine years, or less than one per cent. These ties were all mixed oaks, no white oak included.

The Burlington treated 5,620,340 ties with the Burnettizing process during the nine years from 1900 to 1908. A careful record kept of these ties shows 38,431 removed for all causes, inclusive, and 32,100 removed account of decay. This is less than one per cent removed after nine years. These ties were almost all lodgepole and bull pine, and douglas fir, and were used only in the dry climate of Wyoming, South Dakota and Western Nebraska.

A series of leaching tests were made to determine the rate with which zinc chloride leaches from timber treated with the Burnettizing process. Lodgepole pine and douglas fir ties were used. Some of the ties were seasoned six months after treatment and before the test for leaching was begun, and others were freshly treated and were full of the water solution.

To carry out this test a number of pans were constructed large enough to submerge an entire tie with water. The object of the test was to determine whether zinc chloride would leach out from ties as rapidly as we were inclined to think would be the case, and also the relative leaching of seasoned over freshly treated ties. The ties were first carefully treated, and weighed before and after treatment, to find, as nearly as possible, the number of grains of pure zinc chloride absorbed by each tie.

To determine the amount of zinc chloride leached out, each tie was placed in the pan filled with water and left 24 hours, after which it was taken out and allowed to dry six days. This process was repeated continuously for many months. After each soaking a measured quantity of the water was taken from the pan and the amount of zinc chloride determined.

The accompanying diagram shows graphically the results of this experiment:

Line "A" represents freshly treated douglas fir ties.
Line "B" represents seasoned bozeman fir ties.
Line "C" represents seasoned lodgepole pine ties.
Line "D" represents seasoned douglas fir ties.

A study of these results shows that in carrying out a leaching test in this way, less than 30 per cent of the zinc chlorides can be gotten out of the wood in nearly a year's time, and that the largest part or approximately 18 per cent is leached out in the first 70 days. It also shows that with the freshly treated ties, the leaching was much more rapid, almost the entire loss being within 70 days.

Dr. Von Schrenk, in bulletin 41, Bureau of Forestry, has shown very clearly the manner in which salts soluble in water leach out, and the tests given above serve to emphasize the recommendations he has made that all zinc treated ties should be thoroughly dried before being laid in the track.

If more care were given to the proper drainage of the roadbed, no doubt ties would show a greatly increased life, and the money spent for labor in doing this might return good interest on the investment. While this especially applies to ties treated with a water soluble salts it is no doubt true to a greater or less extent of ties treated with any preservative.

To illustrate this point: The sketch, Fig. 1, represents a cross section of road-bed, on which a short spur was run out about 200 feet from the main line. Flat cars were set on this track and heavy rock loaded on to them from one side. On the side from which the rock was loaded was a bank of earth two or three feet higher than the track, and in the process of loading the rock, the earth was forced down over one end of the tie as shown. This earth, kept moist by rains, caused some of the zinc chloride, with which the ties were treated, to leach out. As fast as the zinc leached out, decay set in, gradually destroying the ends of the ties which were covered. The opposite ends of the ties where there was drainage showed no signs of decay, and were in as good condition as when first treated two years before.

The cut, Fig. 2, shows how these ties looked after being taken from the track. An analysis showed practically no zinc in the decayed ends, while the solid ends were well treated.

With some processes, air seasoned ties only can be treated, while with others either seasoned or unseasoned ties may be treated, the latter being artificially seasoned in the retorts by steaming. The question is often asked whether it is more economical first to season the ties in the yard, or to season them artificially in the retorts, and thereby treat them immediately as delivered to the plant.

This is a somewhat difficult question to answer; there are so many factors to be taken into consideration, and what would apply to one locality may not necessarily apply to another. First, we would have to decide what is a seasoned tie. In the South a pine tie may be seasoned thoroughly in two months. In the North it may require three to six months, and even longer. For example, let us take a plant situated in one of the northern states, say Illinois, for I am better acquainted with that climate. We will assume that we have a plant with a capacity of treating 1,800,000 seasoned ties annually, and that it will require an average of six months to air season the ties for treatment, necessitating the storying of 900,000 ties continually. Of course, ties will season more rapidly in warm weather than in cold weather, and some kinds of wood more rapidly than others, but the average may not be far from six months. We must further assume that we are using a process which can be adapted to either seasoned or unseasoned timber. We will also say that thoroughly seasoned ties can be treated in six hours, and that unseasoned ties will require nine hours, or in other words it will require one-half longer time to treat unseasoned timber. Of course this will vary one way or the other but this is no doubt a fair average.

The above statement results shows that to treat thoroughly seasoned ties, the cost is 0.1895 per tie; whereas, the unseasoned cost 0.1997 per tie, or a difference of 0.0102 in favor of seasoning. This multiplied by 1,800,000, the capacity of the plant, represents a saving of $18,360.00 per year.

In addition to this saving, there would no doubt be other advantages, such as a better penetration by the preservatives thereby getting a greater life out of the ties, and reducing the liability of weakening the timber from excessive steaming. Another important factor is that in steaming there is always a large amount of sewage to dispose of, while in non-steaming there is practically none. The disposition of sewage is always a difficult problem at any plant, because no matter how you handle it, it will eventually get into the rivers or creeks and pollute the water supply to such an extent that damage suits may result sooner or later.

A record should be kept of treated ties to show what life is obtained under different conditions as compared with untreated ties. This is usually done by driving a dating nail, with the year number stamped in the head, into each tie when it is

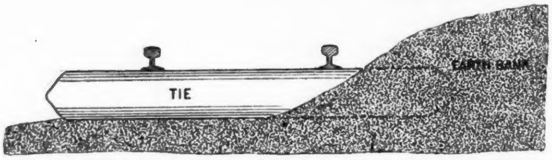


Fig. 1.

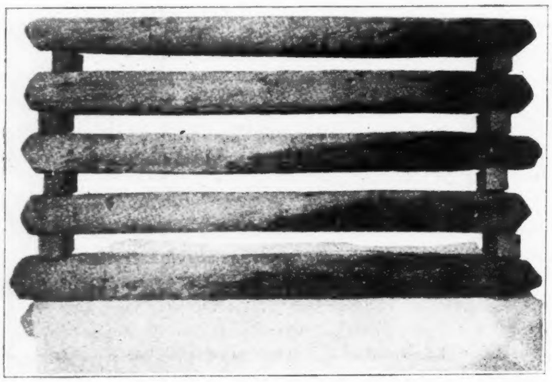


Fig. 2.

SEASONED TIES

CAPACITY OF PLANT 1,800,000 PER YEAR

Unloading from cars to ground to season at 0.0070 each	$ 12,600.00
Loading from ground to trams after seasoning at 0.0055 each	9,900.00
Switching trams from yard to retorts at 0.0020 per tie	3,600.00
Loading treated ties out at 0.0065 each	11,700.00
Fixed expenses	28,800.00
Preservatives at 0.150 per tie	270,000.00
Fuel (assume 1/3 less for seasoned over unseasoned ties)	6,000.00
Insurance on 900,000 ties (estimated)	3,000.00
Interest on 900,000 ties, or say 5% on $450,000	22,500.00
	$368,100.00
600,000 more seasoned ties treated than unseasoned, worth 0.0451 each. (See part 12)	27,060.00
	$341,040.00

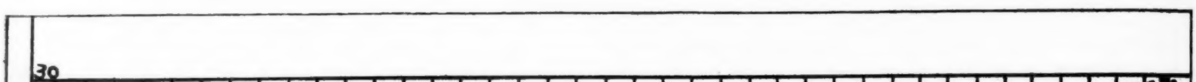
$0.1895 per tie.

UNSEASONED TIES

CAPACITY OF PLANT 1,200,000 PER YEAR

Unloading one-sixth from cars to ground to enable prompt releasing of cars, and to insure a continuous supply so as not to delay plant at 0.0070 each	$ 1,400.00
Loading 1,000,000 ties from cars to trams for treatment, and 200,000 ties from ground to trams at 0.0055, each	6,600.00
Switching 200,000 ties from yard to retorts at 0.0020	400.00
Loading treated ties out at 0.0065	7,800.00
Fixed expenses	28,800.00
Preservatives at 0.150 per tie	180,000.00
Fuel (estimated)	9,000.00
Insurance on 200,000 ties (estimated)	665.00
Interest on 200,000 ties, or say 5% on $100,000.00	5,000.00
	$239,665.00

$0.1997 per tie.



placed in the track. A better way, perhaps, is to drive these nails in the ties immediately after they are treated at the treating plant. This will, at least, insure that every tie has a dating nail, whereas, if it is left to several hundred section men many ties will be put in the track without dating nails.

Section foremen should be instructed to make a monthly statement giving the number of treated ties laid and removed, with dates treated, and should give cause of removal whether from decay, rail cut, broken, burned, etc. At the office where the permanent records are kept (preferably at the timber treating plant) these monthly statements should be recorded, keeping a separate record for each section. An annual report can then be made to the management showing results of the treatment.

No reliable information can be expected from the section men as to the different kinds of timber, because probably not one in fifty can tell one kind of wood from another, especially after it is treated. In order that accurate knowledge may be obtained as to the relative life of the different kinds of wood, special tests should be made. On the Burlington this was done by treating twenty kinds of wood with several different processes. 1,000 ties were carefully treated and placed on each of the eighteen divisions of the system. Each kind of wood and each process was marked with a special nail so that the tie could be identified at any future time. Each lot of 1,000 ties were placed in one continuous stretch of track, and the different kinds of wood grouped together, alternating with the different processes

and every seventh tie was untreated. While the number of ties used in this test is comparatively small, it is hoped the results obtained will give a fairly good idea of the relative value of the different kinds of wood used for cross-ties.

A plant consisting of three treating cylinders, each six feet in diameter and 132 feet long, will have a capacity of about a million and one-half ties annually. Estimated cost of plant, $175,000.00. The life of such a plant is estimated to be at least fifteen years.

To arrive at the cost of treating ties the following items are considered:

First—Interest. $175,000.00 invested at 5 per cent compound interest for fifteen years represents an annual charge of $12,587.00.

Second—Depreciation. Estimating the life of the plant at fifteen years, we will charge off 6 2-3 per cent, or $11,666.00 annually.

Third—Insurance. The stock of ties, as well as the buildings should be insured and a reasonable estimate may place the annual premium at $5,000.00.

Fourth—Freight on Ties to Plant. It would not be right to charge all freight on ties to the treatment, but it may be reasonable to assume that every car of ties for treatment is hauled on an average of 100 miles, and we can base the freight haul on a rate of ½ cent per ton per mile. Also estimate that cars will hold an average of 390 ties each, and that the ties will average 135 pounds in weight. Thus, a million and a half ties will require 3,846 cars to haul them to the plant, and these ties weigh 101,250 tons. This represents an annual expenditure of $50,625.00.

Fifth—Switching. To switch 3,846 cars of ties, plus approximately 500 more containing preservatives, fuel, etc., or say a total of 4,346, in and out of plant at fifty cents per car, will cost $2,173.00.

Sixth—Per diem on Cars. It is not always possible to unload ties the same day received, in fact it often happens that they are delayed a week or more from one cause or another, in which case we are called upon to pay a per diem charge of 25 cents or 50 cents. For our present purpose it may be reasonable to estimate $1.00 per car, or an annual cost of $3,846.00.

Seventh—Operating Plant. This will include all labor and material other than itemized above, estimated $300,000.00.

We do not know just what life these ties will give, but it may be fair to assume twelve years for treated ties, and six years for untreated ties, or in other words, treating will double their life. For our purpose of comparison we will not consider tie plates in either case.

UNTREATED TIES.

(Life Assumed as Six Years.)

First cost of tie (estimated)	$0.500	
Insurance, interest, freight, etc. (as per statement "A")	.0435	
Cost of putting in track	.150	
Cost of tie in track		$0.693
5% compound interest on investment for six years		0.2320
Second renewal end of six years		0.6935
5% compound interest on 1st investment for six years and 5% on 2nd investment for six years.		0.5503
		$1.4758
Total cost of tie for period of 12 years		$2.1693
Average cost per tie per year		0.1808

TREATED TIES.

(Life Assumed as 12 Years.)

First cost of tie (estimated)	$0.7572	
Cost of putting in track	0.15	
Cost of tie in track		$0.9072
5% on $0.9072 for 12 years		.7220
Total cost of tie for 12 years		$1.6292
Average cost per tie per year		.1357
Saving per tie per year		.0451

Taking capacity of plant at 1,500,000 ties, this would show an annual saving of $67,650.00, which is nearly 39 per cent on the original investment of $175,000.00.

Summary.

	Total Cost per Yr.	Cost per Tie
First—Interest	$ 12,587.00	$0.0084
Second—Depreciation	11,666.00	.0078
Third—Insurance	5,000.00	.0033
Fourth—Freight on Ties	50,625.00	.0337
Fifth—Switching	2,173.00	.0014
Sixth—Per Diem on Cars	3,846.00	.0026
Seventh—Operating Plant	300,000.00	2000
	$385,897.00	$0.2572

Untreated Ties.

	Total	Per Tie
Insurance (assumed to be the same as with treated ties)	$5,000.00	$0.0033
Freight (assumed to be one-half as much as with treated ties)	25,312.50	0.0169
Switching 3.846 cars of ties in and out of storage yards at 50 cents per car	1,923.00	0.0012
Per diem on cars (assumed to be the same as with treated ties)	3,846.00	0.0026
Handling ties in storage yard (unloading 1,500,000 ties from cars to ground at $0.007 each, and loading from ground to cars at same rate)	21,000.00	0.0070
Interest on 750,000 ties, or 5% on $375,000 (assuming that one-half the ties are in the storage yard constantly)	18,750.00	0.0125
	$75,831.50	$0.0435

(To be continued)

New Pencil Woods

Recent conferences of representatives of the department of Agriculture with several lead-pencil manufacturers have resulted in plans for testing new woods in reference to their use in the pencil industry. According to some of the manufacturers, the supply of red cedar, which furnishes practically all the wood for the annual output of some 325,000,000 pencils, will be exhausted within five years. A substitute must be found which will whittle easily, contain a large amount of material free of knots, not be porous, nor spongy, nor unduly hard, and which shall occur in sufficient quantities to meet the needs of the industry.

Therefore the Forest Service is to co-operate in a test of a number of woods. Among those to be tried are Rocky Mountain red cedar, alligator juniper, western juniper, redwood, incense cedar, western cedar, Port Orford cedar, and Alaska cypress. Specimens collected from the national forests will be sent to four leading manufacturers, who have agreed to make pencils of them, and keep a record of the tests reporting the results, as well as their judgment as to the fitness of the individual woods to the Forest Service.

The Forest Service is assisting in this experiment because there are on the national forests large quantities of junipers and cedars which may be suitable for pencil making. For several of these woods no very valuable use has yet been found. Foresters believe that in the future the woods from the national forests may, to a considerable extent, come into use to supplement the diminishing stock of eastern woods, which have received no protection.

Waterproofing Engineering Structures

By Joseph H. O'Brien, Member Boston Society of Civil Engineers.*

The purpose of this paper is to present some points of possible general interest, and briefly to describe waterproofing by use of pitch and felt, of certain viaducts, retaining walls, cut and cover tunnels, pipe subways, elevator pits, conduit banks, etc., which have been designed and constructed in New York City under my supervision. The work to be described was performed under three separate contracts, but the materials used were the same in each case, the specifications varying only as to number of plies, methods of procedure and character of backing, or protection of waterproofed surface.

The clauses of the specifications, which apply to materials and application, are as follows:

"Pitch used shall be straight run coal-tar pitch, which shall soften at 60 degrees fahr. and melt at 100 degrees fahr., being a grade in which distillate oils distilled therefrom shall have a specific gravity of 1.105."

"The felt shall be 'Hydrex' felt manufactured by F. W. Bird & Son, East Walpole, Mass.,† or felt equally satisfactory to the engineers."

"Pitch, when applied, shall be of a temperature of not less than 250 degrees fahr. The pitch shall be mopped on the surface of the masonry to a uniform thickness of not less than 1-16 in. Each layer of pitch must completely cover the surface on which it is spread without cracks or blow holes. The felt must be rolled out into the pitch while the latter is still hot and pressed against it so as to insure its being completely stuck to the pitch over its entire surface. Great care must be taken that all joints in the felt are well broken, and that the ends of the rolls of the bottom layer are carried up on the inside of the layers on the sides, and those of the roof down on the outside of the layers on the sides, so as to secure the full laps herein specified."

Other important clauses are:

"It is intended that the interior of waterproof structures shall be permanently free from moisture or discoloration due to

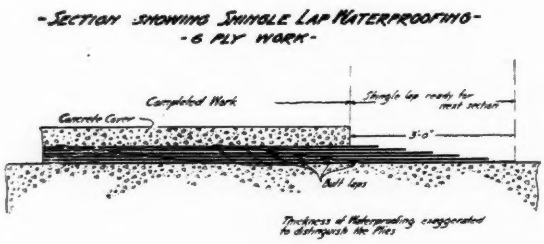


Fig. 1.

the percolation of water or other liquids from outside sources. This end shall be attained by means of a continuous flexible waterproof sheet surrounding the exterior of the structure.

"Waterproofing must be protected against injury at all times to the satisfaction of the engineers."

"Any waterproofed structure that is found to leak at any time prior to the completion of this contract, shall be made tight by the contractor in a manner satisfactory to the engineers."

"Waterproofing will be measured by the square of 100 superficial feet and paid for accordingly."

Composition of the waterproof sheet is specified as follows:

"For all construction, except electric conduit lines and electric conduit manholes, waterproofing shall consist of six layers of felt and seven layers of pitch alternating, and shall consist

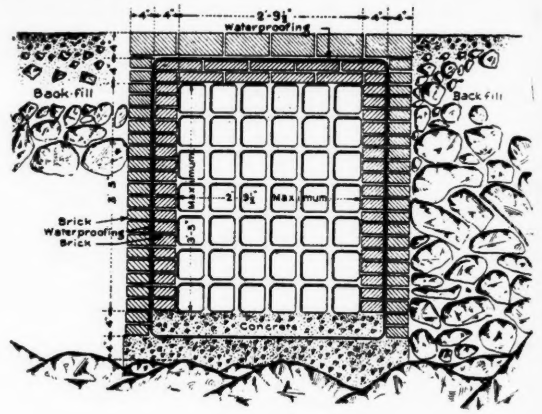


Fig. 6.

of four layers of felt and five layers of pitch alternating, for electric conduit lines and manholes, each strip to lap not less than 1 ft. upon the previously laid strip, and each section of waterproof sheet shall lap at least 1 ft. with the adjoining section."

The specifications have, in most particulars, served their purpose admirably, but the following comments may be of interest: The felt used comes in rolls 36 in. wide, and each roll contains 400 sq. ft. The method of practical procedure to be followed in placing the felt so that the specification requirements as to laps might be complied with, caused much concern.

In my judgment, the most effective way to lap the plies is by the "shingle method," or, as sometimes called, the "feather-edge method," similar in principle to that employed in pitch and felt roofing; but it is evident that with felt sheets only 36 in. wide, the prescribed lap of 12 in. cannot be effected in six-ply work by the "shingle method," and because of the superiority of this method, it was concluded to fit the laps to the felt, and the work was actually carried out wherever practicable with 6-in. laps "feathered-edged" or "shingled." The felt was laid transversely of the structures. The requirement "each strip to lap not less than 1 ft. upon the previously laid strip" occasioned some confusion, owing to the fact that it might be interpreted to mean that each 36 in. strip should lap the prescribed amount at edges and ends over the previously laid strip of the ply of which it was a part, but as this was manifestly impracticable, the requirement was interpreted as applying to the relation of the joints in one ply to the joints in the ply beneath it, as was doubtless intended; but, as said above, the lap was reduced to 6 in.

The usual waterproofing practice of sticking each strip to its neighbor by lapping at least 1 in. was followed in making up each ply. I believe that a better result will be obtained, however, if this butt lap (so called) be made 2 in. wide.

The system of shingling adopted keeps the shingle at the head of the work with all six plies in evidence, and with all sheets securely stuck, as shown in Fig. 1. Thus the waterproof sheet is entirely completed back of the shingle lap, and may be covered and permanently protected up to the lap. By this method there is little difficulty in obtaining the correct number of plies, and, in my opinion, the method gives the best obtainable quantity of work.

In providing for connection of two sections of standing work, as in subways, or for connection of standing work and flat work, as at tops of walls, dry laps were left, which appeared at first to be the only solution of the problem which would insure a continuous waterproof sheet of the character intended; but on six-ply work this procedure required that dry ends of sheets varying from 6 in. to 36 in. be left, in order to effect the shingle bond with the flat or standing work, as the case might be. (See Fig. 2.) Despite the specification requirements that "water-

*Read before the Society.

†Now the Hydrex Felt and Engineering Company.

proofing must be protected from injury at all times to the satisfaction of the engineers," I do not hesitate to say that it was quite impracticable to protect dry laps, and despite all efforts made to do so, such laps were invariably found almost wholly destroyed and unfit to join on to, when ready to proceed with the connecting waterproofing.

The destruction of dry laps was due to various causes, such as dragging timber and other materials over them, deposits of débris and of concrete from the work preceding the next waterproofing stage, traffic of laborers over them, and last, but by no means least, the absorption of water. If the felt becomes water-soaked, it is thereby destroyed. The saturation and coating of high-grade felts, such as that used on the work described herein, renders the sheets impervious to water on their surfaces, but the edges are not impervious, hence the necessity for so conducting the work that the edges of the felt be at all times protected from the influence of water.

To overcome the trouble experienced with dry laps, the total lap was reduced from 36 in. to 24 in. for connections of standing work, sticking the two first sheets solid on the top of the backing wall, leaving four dry laps of 6 in., 12 in., 18 in., and 24 in. for the remaining plies. (See Fig. 2.) Then when the joining was effected, four plies were carried through by shingle method, and two plies were stuck by solid lap method. Due to the reduction in width of total dry lap, the felt was more easily preserved, but the destruction of these laps was not wholly avoided.

I believe that, under similar conditions, the best procedure would be to reduce the dry laps to two plies and stick four plies with solid lap. This solution of the difficulty is wholly a practical suggestion, which does not satisfy theoretical consideration of the problem, but will none the less give good results.

The instances of dry laps so far discussed and illustrated were an incident of the construction of the reinforced concrete subways, for pipes, wires and express trucking, about a mile of which, varying in clear width from 6 ft. to 17 ft., have been constructed beneath track grade. The procedure which brought about the above-noted conditions may be more readily understood if we depart a little from the subject and briefly describe and illustrate a typical subway. The cross-section (Fig. 3) shows a subway 12 ft. wide, varying from 12 ft. to 17 ft. high inside, designed to carry a railroad on its roof, and to resist hydrostatic pressure, due to an assumed head, measured from the average level of the open joint drainage system, which is about 1 ft. 6 in. below the roof of the subway. It will be noted that the excavation is wholly in rock, and the drawing requires that a volume be excavated only 6 in. wider on each side than the neat section. The nature of the rock was such, however, that the trench was blown out from 5 ft. to 10 ft. wider than required in places.

The first step after completing the excavation was to build the floor base and backing walls ready for waterproofing.

After careful consideration, it was determined to make the backing walls 12 in. thick, and to limit their height to 4 ft. in the first stage. (See Fig. 2). The height determined upon was sufficient to keep water out of the waterproofed trench, except occasional flooding after heavy rains, and it was a convenient bench from which to work in placing rod reinforcement against interior forms, and upon which to construct exterior forms of the subway. It was considered, owing to lapse of time which must ensue in constructing the monolithic tube within the waterproof enclosure, that standing work would probably often be lost if carried higher than 4 ft., by sags due to weight of fabric and augmented by temperature exposure. Likewise the danger of damaging the fabric while building the reinforced tube inside of it was anticipated. Fears in respect to these matters were fully justified, as illustrated, by the case of an 8-ft. subway, which was so situated that the complete waterproof sheet had to be placed up to the roof connection, and the subway built within.

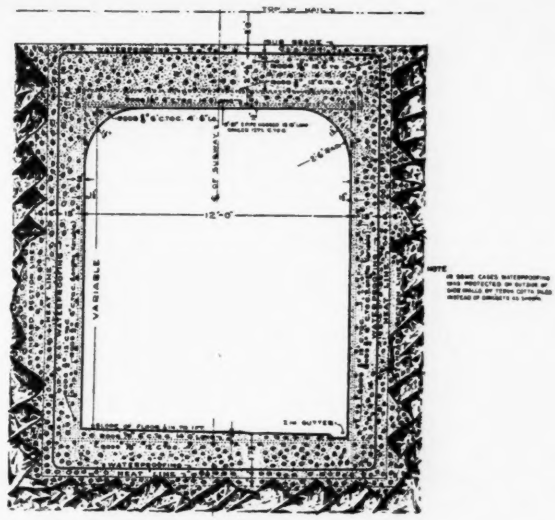


Fig. 3.

Much valuable waterproofing work was destroyed in this trench, due to the causes cited.

Another point bearing upon the practical application of the felt in the first stage of the subway waterproofing, above referred to, and in similar situations, is the importance of so making angles and corners that they will be durable during construction and tight after. Angles at junction of flat and standing work are natural weak spots in pitch and felt waterproofing.

In the subways referred to, the first scheme tried required that the sheets be carried full across the floor and up both backing walls in one continuous strip, but two very serious objections to this procedure soon became evident. In the first place it was impracticable to stick the sheets securely throughout, especially at the angles of floor and walls, and as a result, the standing work bulged and sagged. In the second place, the scheme resulted in much waste of material, and annoyance to the contractor, who was accustomed to cut and fit according to his material, with a minimum of waste.

The method was changed, therefore, so that the floor plies

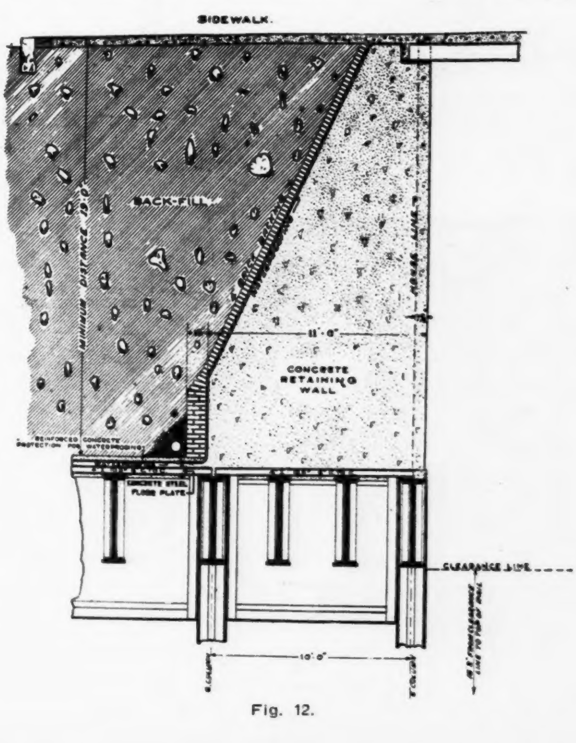


Fig. 12.

would break joint with the wall plies, partly on the wall, and partly on the floor, as shown in Fig. 2-A, and as an additional safeguard a strip was laid longitudinally and fitted snug into the angle over all, and this was found to be a very practical and satisfactory solution of the detail.

Fig. 4 shows the waterproofing of floor and backing walls, proceeding according to the method last described. Fig. 4-A clearly shows the method of waterproofing backing walls of subways. It was found necessary to leave openings in the walls of pipe subways for pipes varying in diameter from 1½ in. to 12 in., and in order to insure a watertight job upon completion, screw sleeves with sheet lead washers, and with calking rims were devised, as shown in Fig. 5. Th epipe sleeve details were designed to permit of the introduction of the pipes after the subways had been completed. The sleeves were easily applied and the use of them has so far resulted in tight work.

In conduit bank waterproofing, several miles of which were included in the work herein described, dry laps were left at first on the flat at the floor base, owing to the necessity for laying the conduits in advance of placing the side wall and roof waterproofing. Fig. 6 shows section of typical conduit bank, and Fig. 7 shows first stage of waterproofing with dry laps.

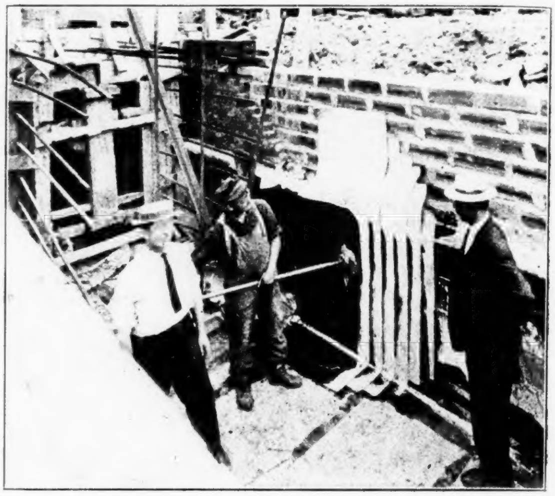


Fig. 4-A.

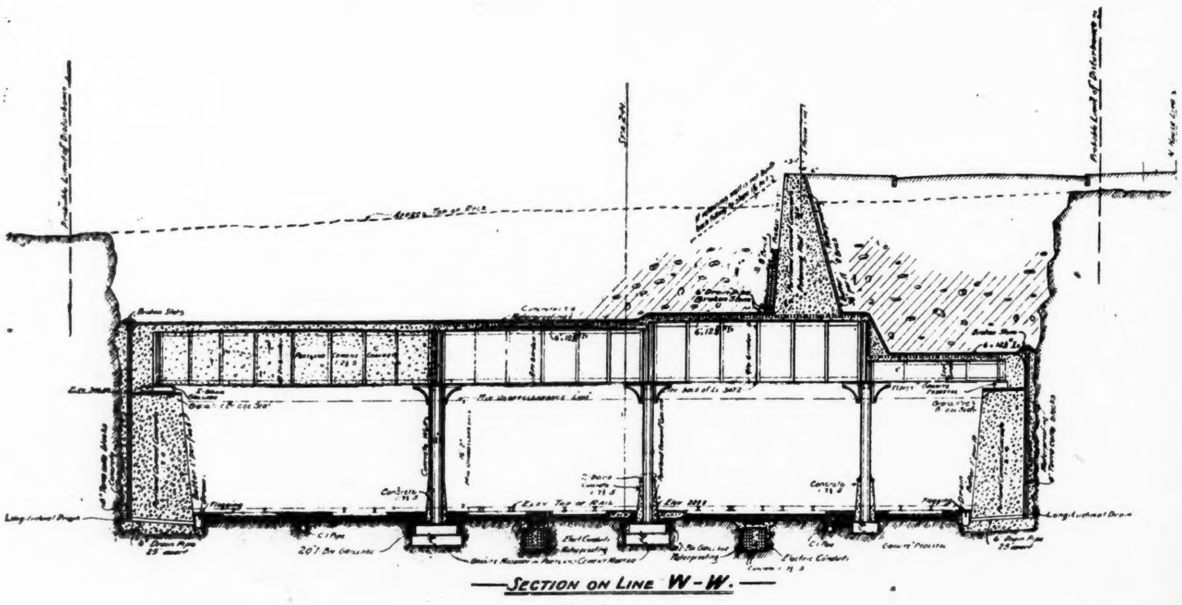


Fig. 10.

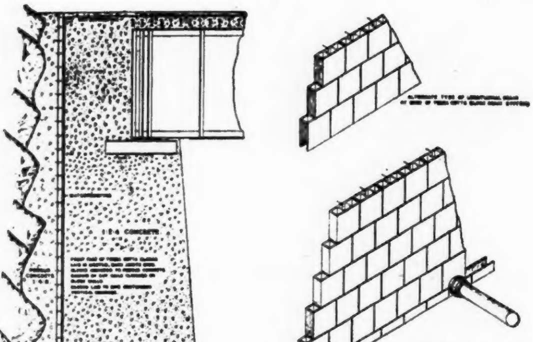


Fig. 11.

Practically all of the laps beyond the edge of the masonry base were found to be destroyed when the conduits had been made ready for completion of the waterproofing, hence the laps were reduced successively to two dry and two stuck, and finally to all four stuck of the width of base projection beyond the conduits. Wherever conditions made it possible to require the construction of the complete waterproof basin to the top of the conduits in advance of laying the latter, this practice was followed, but while it produced the best job of waterproofing, it required the construction of the conduit bank end on in a narrow trench, at the risk of bad duct alignment. Furthermore, the rate of progress by this latter method was very much less than by the method generally followed.

In my judgment, however, and despite the fact that tight work has been obtained by the method of first placing the floor sheets, joining the wall and roof sheets to them, after the duct bank was made ready, it would be better, where similar work is required, henceforth to design the waterproofed trench of sufficient width, and with suitable backing walls to permit of the construction of the ducts in the usual manner, after the trench has been completely waterproofed.

Waterproofing of baggage lifts pits was placed in accordance with the principles outlined above for pipe subways, but the pits were open at the top and one end, and the waterproofing problem was complicated by the presence of foundations for superstructure columns, and by the necessity of providing for plungers.

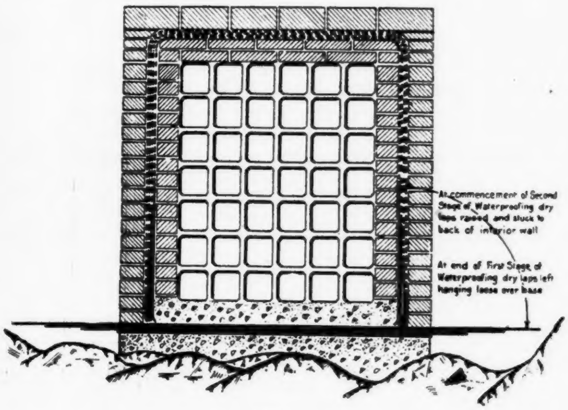


Fig. 7.

It was determined that the plunger borings should be made after the baggage lift pits were completed, and to insure a water-tight pit, a plunger casting was devised, with a clamping ring and stud ring, between which the waterproofing was placed (See Fig. 8).

This casting had to be set accurately and securely in position, hence the base course of concrete was carried through beneath it, and the casting was set on this course, and stayed by lateral bracing during the placing of the finished work. The detail of the casting required that the connecting sheets of waterproofing be cut to fit the stud bolts, which was a rather unusual waterproofing detail, but a very satisfactory result was obtained.

Due to a necessity which arose, bearing upon the general advancement of the project, the backing walls of two baggage lift pits, which had been excavated for most of their height through earth, were placed in the form of retaining walls some months in advance of the completion of the lift pits, and construction tracks were carried over them on temporary trestle stringers. After the floors of these pits were completed, the steel framing of the walls (composed of 15 in. I-beam studs, set apart 4 ft. 0 in. centers) was erected, in advance of completing the waterproofing, because it was feared that the waterproofing, if completed first, would be destroyed during erection of the steel. The procedure followed made the placing of the waterproofing a very difficult job. To overcome the difficulty, mats were prepared to fit the spaces behind the beams. These mats were made up of sheets varying in width from about 12 in. for the sheet next to the beam flange to 36 in. for the sheet next to the backing wall. The mats were made up and mopped complete on the adjoining subway roof, and were lowered into place and securely stuck. After any two mats of a panel had been placed, the intervening space was waterproofed in the usual manner. The joining between floor and wall work was effected by solid lap method, and the joint was protected by three courses of brickwork in Portland cement mortar, set about 3 in. away from the wall waterproofing, thus forming a pocket which was filled with pitch.

In the case of one viaduct which was constructed under an avenue, the waterproofing was placed to full height of walls, and turned down on top before the backing was placed, dependence being put in the adhesiveness of the waterproofing, and weighting down of top while backing was laid. When the backing followed immediately after waterproofing, this scheme worked out all right, but when the backing was delayed, the waterproofing sagged and bulged badly, and in some cases had to be renewed. Hence on walls and elevated railway foundations of another avenue viaduct the waterproofing was carried up in first stage to height of 5 or 6 ft., the work being stuck securely in each stage and backed up immediately.

Due to necessity for transfer of street railway, sewer, water and gas pipes from temporary to permanent supports, during construction of the latter viaduct the floor plate work had necessarily to be finished in some instances within 18 in. to 20 in. of walls and piers in advance of waterproofing the latter. In such instances the shingle lap method was abandoned and the floor waterproofing was carried through solid against the walls or piers, and when these were ready, a six-ply flashing of waterproofing was placed over the angle of floor and wall and extended up the wall, and out on to the floor waterproofing. Over this flashing the wall waterproofing was placed and carried out over full width of exposed floor waterproofing, making a very satisfactory job of solid lap work. Fig. 9 shows the application of waterproofiing to walls, also flashing of angle of floor and walls in manner last described. Fig. 9-A shows waterproofing in progress on the deck of a viaduct under a street, and is introduced to show the more simple type of viaduct roof work. Fig. 10 shows a cross-section of a cut and cover tunnel.

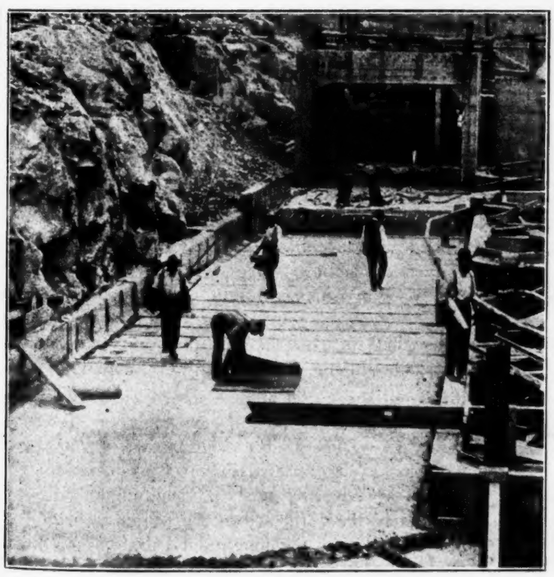


Fig. 4.

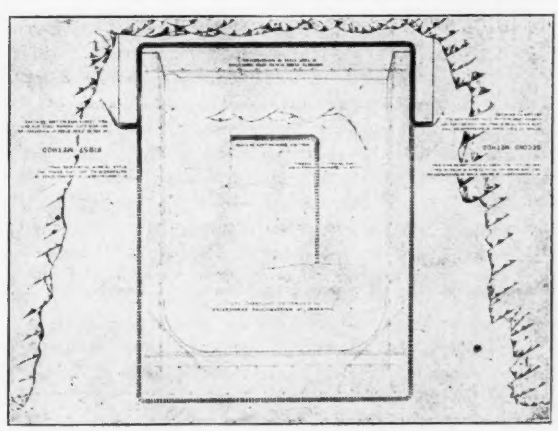


Fig. 2 and in Middle Fig. 2-A.

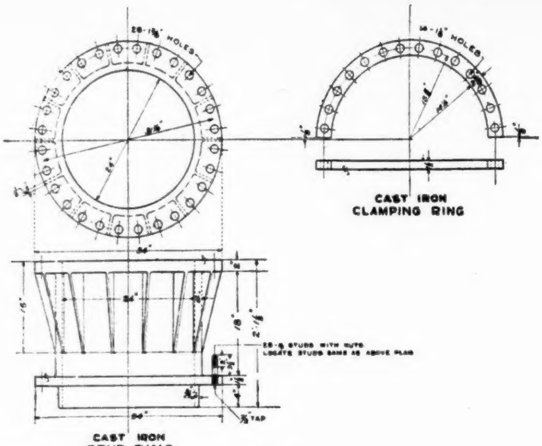


Fig. 8.

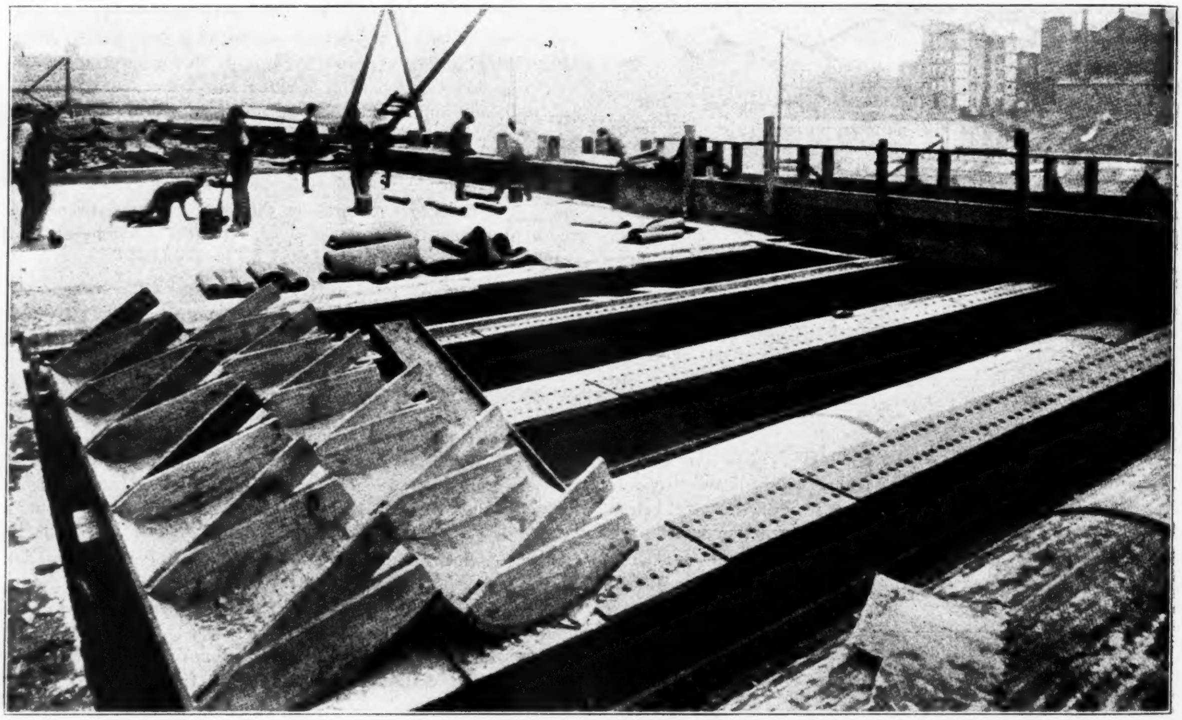


Fig. 9-A.

The principles of application of the waterproof sheets hereinbefore described for other work apply with equal force to this cut and cover work. I will, therefore, briefly describe the mode of procedure in the general construction of this work, so that a few points of interest may be brought out, which are partially, though not wholly, related to the waterproofing problem, but which are of sufficient value to warrant description. As will be noted by reference to Fig. 10, the tunnel roof is composed of steel girders resting on concrete abutment walls and intermediate columns, all founded on solid rock. The excavation from an average elevation of 10 ft. above the roof was entirely in solid rock, and owing to franchise requirements, together with the fact that a portion of the work encroaches on very valuable private property, it became the engineer's duty to restrict the over-all width of the excavation to a minimum.

The roof of the structure is at an average depth of 20 ft. below street level and about 9 ft. below sewer level, and the track sub-grade is at an average depth of 49 ft. below street level, 38 ft. below sewer level, and 12 ft. below mean high water.

It was apparent that, owing to these conditions, some surface water and the ground water below sewer level would have to be effectually shut out, and under less restricting conditions the design of abutment walls, capable of resisting hydrostatic pressure due to a head measured from bottom of sewers, might be warranted. After due consideration, however, it was determined to design the abutment walls of suitable section to safely support the vertical loads to be carried by them, trusting to a free drainage scheme to relieve these walls of hydrostatic pressure. I devised a free drainage scheme, wheih is illustrated by Fig. 11, and which, owing to the fact that it has been completed and doing good service for over a year, may be pronounced a success.

The scheme consists of the application of well-known materials in a simple but unusual manner, namely, the space from standard section line to ledge, varying from 6 in. to 4 or 5 ft., was filled back of a form to full height of abutment walls with a porous concrete, 1 part cement, 4 parts sand and 8 parts broken stone. This porous backing was faced with hollow, light-burned, porous terra-cotta partition blocks, 12 in. by 12 in. by 4 in., laid with openings set vertically and bonded for continuity of vertical hollow spaces. These blocks were anchored to the concrete backing by cut nails, clinched over the inner walls of the blocks at joints. The bed joints were butted in such manner that the back half of the joint was left open as far as practicable and the build joints were similarly made.

This tile drainage sheet was at first footed on a longitudinal tile drain, made by splitting out end cells from the blocks and laying them on bed. Dupe to the underburned quality of the material many blocks were wasted in an effort to produce one suitable end cell. Hence the type of longitudinal drain was out to approximately the form shown, by use of a bricklayer's chipping hammer, and thus the longitudinal drain was obtained with very little waste. This longitudinal drain is connected with a gutter at the toe of the abutment wall, which is, in turn,

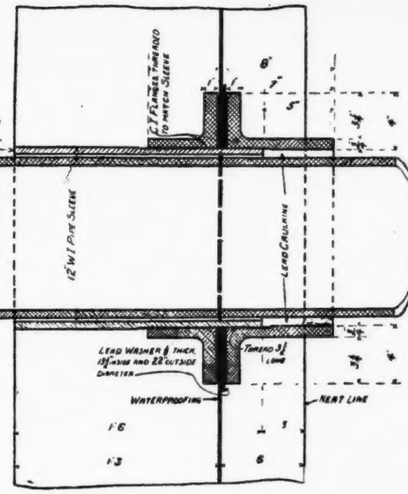


Fig. 5.

connected to the underdrainage system. Upon the face of the tiling described, the wall waterproofing was placed for full height, with dry laps extended over the backing wall and weighted down. A section at a time, varying from 25 ft. to 50 ft., was thus prepared and the abutment walls completed as soon as practicable after waterproofiing.

As may be readily understood by reference to Fig. 10, many months elapsed after waterproofing abutment walls before the roof work was connected and the dry laps were found to be very seriously damaged. The roof work was advanced a section at a time, dependent upon the opportunity for moving equipment, and the roof work sections were of varying areas, and frequently broke part way over the roof. The work was changed to that shown in the upper right-hand corner of the cut. The end walls and partitions of the blocks were chipped all performed by the shingle method, hereinbefore described, but the patchy procedure on the roof was permitted solely because of the contractor's obligation to make the work tight. I am convinced that a better result will be secured if roof or other flat waterproofing is extended full across the work, thereby leaving joints at one edge only.

After the roof waterproofing was completed, it was covered with concrete, varying in thickness from 4 in. to 6 in., and the highways were restored by backfilling over this cover to a height of about 20 ft. So long as the backfilling was kept well back of the end of the completed work, and was stepped off in bench formation, the plain concrete cover served its purpose, but in one case when the backfilling was advanced in bank formation, close upon the completed construction work, the concrete cover broke and the waterproofing was damaged, requiring removal of much backfilling to effect proper repairs. After the occurrence just cited, I had the cover reinforced by Clinton wire cloth, and no further trouble was experienced. This reinforced cover was also used on a viaduct roof which was built after the cut and cover tunnel work just referred to had been completed.

Where excavation for subways below track level was excessive (see Fig. 2), the contractors were not required to fill back solidly against the rock, but were permitted to build 12-in. backing walls of concrete and to backfill behind this. They came to the conclusion that much time would be saved by using terra-cotta blocks for backing up subway waterproofing above the 4 ft. wall shown in Fig. 2, and they were permitted to substitute these blocks laid on bed in the usual manner in Portland cement mortar. Recently it became necessary to remodel a section of the subway work, and the adhesion between the terra-cotta backing and the waterproof sheet proved to be so strong as to require splitting of the blocks in order to remove them.

An 8-in. brick backing was provided for waterproofing on back of viaduct retaining walls under avenues. During construction of one viaduct a settling down and bulging of the backing wall was noted, accompanied by vertical cracks, due apparently to slipping of the backfilling placed against the wall. To overcome the difficulty, the thickness of the backing was changed from 8 in. to 4 in., and a substantial footing was provided, as shown in Fig. 12. No recurrence of the trouble was experienced after the section of the brick backing was modified.

Many schemes were tried for substantial protection of lap joints in cases where these had to be left for long periods of time before connecting work could be placed, but the most satisfactory protection was afforded by covering the lap with 2 in. of clean sand. No special effort was made to obtain better surfaces upon which to waterproof than result from ordinary practice, but I believe that it would be worth while to insist on smooth finish for surfaces upon which to waterproof, so that complete adhesion may be obtained and air cushions, bulges, sags and water pockets avoided, in so far as the quality of the surface waterproofed affects these conditions. When connection of a new to an old section of work is made, the surface of the old work should be thoroughly cleaned by stiff brooms and flexible wire brushes

The felt used on the work described herein was selected after many comparative tests and analyses had been made for the purpose by chemists, and the requirements adopted as a result of their investigation are as follows:

"The felt must be saturated and coated with asphaltic products and must conform to the following requirements:

Fig. 9.

"(*a*) The weight per 100 sq. ft. shall be from 12 to 14 lb., saturated and from 5 to 6 lb. unsaturated.

"(*b*) The weight of the saturation and coating shall be from 1.25 to 1.75 times the weight of the unsaturated felt if coated on both sides, and from 1 to 1.5 times the weight of the unsaturated felt if coated on one side.

"(*c*) The saturation shall be complete.

"(*d*) The ash from the unsaturated felt shall not exceed 5 per cent by weight.

"(*e*) The wool in the unsaturated felt shall not be less than 25 per cent by weight.

"(*f*) Soapstone or other substances in the surface of the felt to prevent adhesion shall not exceed .5 lb. per 100 sq. ft. of felt.

"(*g*) The saturating and coating materials shall remain plastic after being heated to 250 degrees fahr. during 10 hr. The coating not to crack when the felt is bent double at ordinary temperature.

"(*h*) The felt shall be soft, pliable and tough when received from the factory and until placed in the work.

"(*i*) The quotient obtained by dividing the tensile strength in pounds of a strip 1 in. wide, cut lengthwise, by the weight in pounds of 100 sq. ft. shall not be less than 7.

"(*j*) The quotient obtained by dividing the tensile strength in pounds of a strip 1 in. wide, cut crosswise, by the weight in pounds of 100 sq. ft. shall not be less than 3.5.

"(*k*) The strength saturated shall be at least 25 per cent of the strength unsaturated, taken lengthwise.

"(*l*) The strength saturated shall be at least 15 per cent of the strength unsaturated, taken crosswise."

The pitch used differs from the coal-tar pitch known to the waterproofing trade in New England. It is received on the work in almost fluid state, and spreads splendidly in average and cold temperatures. It flows too freely in hot weather and does not set so effectively in high temperatures, as the harder coal-tar pitch used for waterproofing in New England. The waterproofers obtained a harder pitch for hot weather work which overcame the objection noted in application. It was at first found to be somewhat unreliable as to quality, but the manufacturers succeeded in making a hard pitch with melting point 110 degrees fahr., which had 36 per cent. free carbon and was considered satisfactory material for hot weather.

It is important that the pitch be not overheated, as it volatilizes and insufficient body remains. The danger of overheating is minimized if a first-class kettleman is employed. Practical tests relied upon by a waterproofer to determine the proper temperature of pitch in the kettle, are first to observe whether brownish fumes rise from the kettle, which are an indication of excessive heating; and second, if the pitch cracks too quickly when spat into, it is too hot, but if a very short interval elapses before cracking, it is heated sufficiently. The degree of kettle heat is wholly dependent upon the grade of coal-tar pitch used. For standing work, the pitch may be advantageously heated less than for flat work. If heated too much for standing it falls away from the mop and much of the body of the coat is lost.

It has been observed that the first coating of pitch will coat a concrete surface which is just damp enough to be dustless better than a concrete surface which is dusty dry. Wet or decidedly moist surface is not suitable for pitch and felt waterproofing. If it is necessary to waterproof a surface which has been under water, the surface should be dried by brooming with sawdust. Cement is sometimes used for this purpose, but the result is not quite so effective and it is a more costly method. It requires from 2.5 to 3 gal. of coal-tar pitch per mopping for one square, or 18 to 21 gal. per square for six-ply work.

The quantity of waterproofing placed on the work described herein is 1,000,000 sq. ft.

In closing I wish to call attention to the need of practical inspection on waterproofing work. An experienced waterproofer, familiar with the tricks of the trade, and possessed of the proper temperament for the position of inspector, may readily become a most valued assistant to the engineer in charge.

The Maintenance of Way Department

The Section Forces in Railroading.

(Continued.)

Mr. Bigelow.—Mr. President, in relation to the question brought up by one of the speakers about not getting the ties in time on account of the purchasing agent not getting them purchased and delivered quickly enough, I think that that same trouble often comes up in other departments, and that anything that would bring to the purchasing agent the necessity of the different departments receiving material on time and when it is needed, and the amount of money that can be saved by so doing, even if the material costs a little more, would certainly be of great benefit to the different departments in getting their work done on time. It is often impossible to give the detailed kinds and amount of material needed until it is time to use it, but the amount of money often lost by the men puttering along while the purchasing agent is getting bids and trying to save a small amount in the first cost, would surprise the management if they could only get at it. I remember a case in which a certain special tool was needed to do certain work, the requisition was put in, but the work had to go on even without the special tool which did not arrive until a long time after the work was finished, when it came in from a western city, where it had been bought for a little less than it could have been obtained locally. This helped to make a better showing for the purchasing department, but cost the company many times the total cost in extra time, and cases similar to this happen more often than is realized.

Mr. Wm. H. Hampson.—Mr. President, I would like to hear from some of the gentlemen here in the New England Railroad Club this evening in regard to the maintenance of the rail joint. Gentlemen, that appeals to me. Now I am not in the railroad business, but it always appealed to me, for this reason. I have noticed, more especially on the electric road—take out in Cambridge—that they use a very heavy rail there, and it seems to me it is pretty well placed. Of course the way they surface it is altogether different from the steam roads. But during my travels over the electric roads I find that the rails break about six inches back of the joint. A few years ago, possibly the gentlemen here remember it, they had a machine in Cambridge and they welded the rail joint. I happened to be passing by, and I spoke to one of those gentlemen who was in charge of the road at the time, and I asked him what he was doing. He said, "We are welding these rails together." I said, "I don't know whether that is going to work or not." He said, "What makes you think so?" "Well," I said, "how are you going to figure on your expansion and contraction?" What was the result? They welded them, welded them good and solid too. The rails broke back of the joint, about six inches. Now, I have noticed right along on the electric roads that these great big heavy rails, I don't know what they weigh to the yard but they are pretty heavy, break back about six inches from the joint, and I thought possibly some of the gentlemen here with the New England Railroad Club, being railroad men, could bring up something in regard to the rail joint. I know there is a whole lot of patented devices for chairs and one thing and another, but I notice that two-thirds of the

trouble in the rough riding of some of the roads—I am speaking more explicitly of the electric roads—is in the joints.

Mr. Geo. T. Sampson.—Mr. President, if you will permit me, I would like to speak on just a point which the last speaker mentioned, the matter of rail joints, simply to illustrate, by a practical example, something that has come to my notice. I think it was in June, last summer, I was out with an inspection party, and we rode over a branch line of minor importance and very light traffic, about six miles in length, where we had a four-inch 60-pound rail with an 1880 brand upon it. It was loose in the joints and rattled. The joints were low. Evidently the section foreman had not put in the amount of labor to bring out the best of results, as was demonstrated by changing foremen. An inspection of the dimension of the angle bar joint which was bought with that rail when it was new in 1880, showed that it was in a condition which we call iron bound. Any one familiar with the angle bar knows that it has the effect of a wedge being held in position by the joint bolts. In this case it was a 24-inch angle bar, with four bolts to the joint, a spacing of 5-8-5 ins., rather a broad spacing, in the center. But this was so much worn at the top and base of the angle bar, and on the under side of the rail head, that the inner edge of the angle bar had come in contact with the web of the rail, so that there was no wedging effect whatever, and screwing the nut on the bolt did not improve the joint or make it any safer. But studying the joint I concluded that we might make an angle bar with a greater height, of about 2-32 inch in this case, and put half of it on the top and half on the base, and recommended the purchase of the proper number of angle bars for six miles of this changed pattern. Well, that caused quite a study in the purchasing department and the maintenance department as to how to obtain these angle bars, because the expense of making a set of rolls is quite a considerable item, and the rolls were not in the market. The rail pattern was obsolete, and no more new angle bars could be obtained of exactly the same type as those 1880 rails. But by making inquiry, we obtained a new pattern of angle bar which just about compensated for the 2-32 inch additional height, and only last week I rode over this same six miles of track and was very much pleased with the conditions which resulted from these new angle bars. In other words, those rails, as far as surface and wear is concerned, are good for a great many more years, and these new angle bars have tightened and made that track solid under the locomotive and car, so that it rides nearly—I won't say as good as a new track, but at all events the life of this particular rail is prolonged indefinitely by an expenditure of perhaps $2,000 or $3,000 for six miles. I speak of this as being an experience which is perhaps not altogether new, but at least it is the first time that it has come within my experience where it has been adopted in a wholesale fashion, except perhaps on the main line between here and Providence. Very large changes of angle bars have been made within the last year with a very great improvement, and it has no doubt prolonged the life of rails which were put in the tracks in the 90's of the 100-pound pattern. The old-fashioned way would have been to have taken those 60-pound rails out of the track and sold them for scrap, or put them into yards somewhere where only needed for standing room and where there would be a light traffic, and then put down the new pattern of heavier rail. But the 60-pound rail in this case is ample for the needs of the traffic there, and as I said before, I was much pleased with the results obtained.

I want to add my tribute, too, to the benefits derived from under drainage, and I have in mind many cases. In one place we laid about a mile of continuous piping in a ditch where formerly the water oozed out from the slope of cut, filled the ditch, and in cold weather rolled over even with the top of the rail, sometimes forming over the rail. The laying of this underdrain completely obviated that difficulty. The ditch was back-filled with cinders in the manner mentioned, and that track rides smoothly and the ballast keeps dry and the surface good, and that, and other places where under draining has been adopted, prove the efficiency of that kind of treatment. It is in every way economical. It is a necessity in these days of heavy locomotives.

Mr. Hampson.—Mr. President, I thank the gentleman for his explanation, but while I agree with him thoroughly, here is another thing that has appealed to me that I have heard a good bit of discussion about, more among men particularly connected with electric roads. I am not connected with any electric road, but I have talked this over with some of them. One man will say, the foreman in the gang, "Now, these joints want to be practically opposite when they lay the rail. Here is a joint on one rail, and here is the joint on the other." Another man will say, "No, we don't want them opposite, we want this joint to be further ahead and this one back." I don't know which one is right, and I thought I would bring it up, because some of the gentlemen might probably give us some information on it.

Mr. Bigelow.—Mr. President, if you will permit me, I think I can give a little explanation on the first point he brought up, and that is the question of expansion. It is quite a different proposition on the electric road to what it is on the steam road. On the steam road your rail is entirely above the surface of the ground and is exposed to the changes in temperature. On the electric road, especially in paved streets—I expect this is what my friend had particular reference to—there is a very small portion of the rail exposed to the air and the changes in temperature. The larger portion of that rail is buried beneath the ground. Those rails are a good many of them 9-inch girder rails, and the bottom flange and the web are covered with earth, or paved on both sides, so there is nothing exposed except the top surface, and it is not, therefore, greatly affected by expansion. That is one of the reasons that they can weld the rails in such long lengths and still not have much trouble from expansion, although they do have some trouble, as the gentleman stated. I think that may answer one of his questions.

Mr. Hampson.—Thank you very much; but the reason I brought that up, Mr. President, was the idea, through observation entirely, as to the rails breaking. I have noticed this spring, traveling through a few miles here in this state, that you will find that these men have these great big hack saws, as we call them in the machine business, and they are sawing out a piece six or eight inches back of the joint, and you will find that the rail is broken right off there and hammered down. You can see it in Charles street. To-day I came in, and at those cross-overs in Cambridge street the rails are all broken and crushed right down there, just before you go over the cross-overs, or the frogs or the switches, whichever you want to call them. These men are standing and working there and cutting these rails off back of the joint, and there are places there, say six or eight inches—I have often wondered what was the cause of it—and the rest of the rail is just as good as gold.

Another thing struck me as peculiar on the electric road. Take the outbound rail. Take this place over here on Harvard bridge. They put new rails on a curve as you swing off the bridge coming on to the railroad crossing. The new rails will be there but a very short time, and you will find them all fluted, that is, they are sort of wavy, if that is the proper expression to use. That is on the outbound rail, and it doesn't take but a very short time for it to occur. Of course I probably laid that to the frost, but those are the facts. That is probably up to the maintenance of way on the electric road. I never see that on the steam road. And here is another funny thing about it, I never experienced that in riding in the subway, where the curves are a great deal sharper. That is what always seemed odd to me, that with the same type of cars

running over them, if you take it right out here on curves in Cambridge, Jamaica Plain, or any of these suburban places, you will find that the outbound rail is all wavy and they are renewing those rails continually.

Mr. Snow.—Mr. President, in regard to electric rail breaking about six or eight inches from the joint, I think perhaps an explanation for that, in the case of those which were welded, would be that the rail is steel and that welding heats up a rail to a very high heat for a little distance at the end, and the point where the end of the heat occurs leaves the steel in very bad, brittle condition. That probably is what makes those rails break at that point. We don't find such a condition in ordinary steam railroad practice very often. Of course they sometimes break through a bolt hole, because the bolt hole does weaken the rail a little, but the great proportion of ordinary breaks are not close to the end in steam railroad practice.

The wavy condition that the speaker mentions is what is known among rail cranks as corrugation, and if anybody here, or anywhere else, can tell what causes it and prove his statement he need not work very hard for a living the rest of his days.

Professor Allen.—Mr. President, perhaps I ought not to speak again, but the subject of drainage has come up, and the first man that I know of in this country who called attention very strongly to under-drainage was Mr. Charles Paine, at the time he was chief engineer of the Lake Shore & Michigan Southern, I think in the construction of it. He was an engineer of great distinction, and afterwards president of the American Society of Civil Engineers. Mr. Paine said that there were three important things to be done in connection with the roadbed for its maintenance: the first was drainage, the second was drainage, and the third was drainage. That is the way he presented his subject, and he further said that on some parts of his road he was met by the objection that there were so many bad places on the road that the section gang never was able to get to the point where they had time to try under-drainage: his remark was that if they ever did reach the point where they could try under-drainage and get it accomplished, that after that they would not be so put to it for their time, because the road could be maintained with reasonable economy. That was many years since, and I think was the first systematic and strong presentation of the subject of drainage, which is well recognized now as being of the very geratest importance.

Mr. Asa H. Morrill.—Mr. President, I think the subject has been pretty well exhausted in a general way, but there is one subject that the previous speakers have failed to mention, and that is in connection with the section foreman's reports. As he is the guardian of the company's outlying property, it is his duty to keep his superiors informed of the condition of the track and of any unusual occurrence on his section. When he is appointed section foreman he is immediately presented with a supply of various blanks. Immediately a fire occurs on his section it is his duty to send a wire report to his roadmaster, followed by a written report, making a separate report for each piece of land or structure burned. Upon the occurrence of a derailment he must make report, showing the cause and giving the cost of repairs. In the case of a personal injury or other accident he must also send a wire report, followed by a written report. These reports are the bugbear of the average foreman, and I have a good deal of sympathy for him in this respect.

There is one other point that Mr. Morphy mentioned, and that is "system in track work." The old time foreman would start out with his car in the morning and stop and patch up a piece of fence here, fix a crossing plank there, and chase low joints the remainder of the day. This resulted in keeping a passable track, but never a perfect track. I think the practice to-day on most well regulated roads is so to lay out the work that all foremen will be engaged on the same kind of work at the same time, that is, they would start on tie renewals in the spring, commencing at the point on their sections farthest from home. They would follow this work up until completed, when they would in the same manner proceed with their other duties, such as surfacing, lining, cleaning right-of-way, etc. In this way the roadmaster can gauge his men and has a check on the relative efficiency of the various gangs. He also knows pretty definitely at what points his gangs are working from day to day.

Mr. F. E. Sampson.—Mr. President. The section forces do not take their proper position with other employes, and I think the paper and discussion will help them a good deal. I am in hopes some day to see section labor classed as skilled labor, for it does take skill to line and surface track and put in new ties properly.

I do not think I can add anything more to the discussion.

Mr. L. G. Morphy.—Mr. President, in closing the discussion of the evening I should like to mention one more fact that would perhaps tend to give the section foreman his true relation to the importance of the work that he does. Throughout the paper the figures given for maintenance include not only maintenance of way, but also the maintenance of structures, which means bridges, buildings, etc. Unfortunately I was unable to secure the exact proportion of the expense of maintenance of way to the total cost of maintenance of way and structures for the one year ending June 30, 1908, but analyzing the records back of that, that is, for the year ending June 30, 1907, and prior years, I find that the records agree very closely as to percentages, and it figures that 75 per cent. of the total expense of maintenance of way and structures is for the repairs to road way, rail, ties, fences, road crossings, cattle guards, and other expenses connected directly with the roadway, so that generally and as a matter of interest I would like to say that roughly $243,750,000 of that money was spent for maintenance of way proper.

And in regard to the question of the number of ties renewed per year, per rail length, I hesitated a long time before I put that in, but I have checked it closely, and while that is not an average for portions of heavy trunk railroads it is very close to an average for all the main line and side tracks of the United States, and I might say with our company it is customary to give the requests a rough check on that basis, not necessarily holding each man to that on his subdivision or in his section, but as a total average, including side lines, etc.

In regard to the faithfulness of the emyloyes, I think that is a thing which cannot be emphasized too strongly of section foremen. It has come within my experience to work with men, section foremen, that would work seventy to eighty hours on a stretch, simply taking an hour's sleep as the caboose was detained at a point for a train movement or something of that nature, and those same men were hardy, manly, rugged. And yet you will see those same men cry like children when one of their men is killed. All in all I think that they are a very remarkable and a very admirable set of men.

Letters.

Rail Joints.

Editor, Railway Engineering:

I do not pretend to start anything new in the line of joints, but it appears to me that we ought to get back to first principles in their design. Much brain and brawn is spent on keeping up what we have on our roadway. While we are holding our fingers in the dyke to stay the flow of running repairs, it would pay for some one to devise a scheme to solve the problem, which is one of applied mechanics—nearly simple arithmetic. Two rails are brought end to end and must be fastened together. The joint must keep in line and withstand the weight of and shock due to the pounding of the passing wheels.

The spacing of ties at joints allows for a bending moment at the middle axis. This will vary with the tie spacing. But the section of the joint at the middle point should equal the cross section area of the rail; in other words, the splice should be as strong as the break it attempts to bridge. With a space of ten inches between ties, and rails spiked down on both, we can consider the joint as a beam fixed at both ends, with a load in the middle. Maximum bending at middle would be WL/8, where W is the greatest load on one wheel in pounds, and L the length of span in inches. Applying standard figures to this: $27{,}500 \times 10 \div 8 = 34{,}370$ inch pounds. To this maximum bending we must add the impact or hammer blow of wheel, of 100%. This gives us 68,740 inch pounds. The factor of safety of 5 would bring the total up to 343,700 inch pounds. This is the point at which the design of the joint enters. The resistance of the middle section to breaking must be greater than the strain imposed on it. To distribute the thrust, angle bars are used. But did you ever see an angle bar joint break anywhere but along the line of the middle axis? Here is where the strengthening of our joints should come. The thrust downward due to weight on wheels is the load considered heretofore. Another thrust comes in, and it is outward. This combination of forces to be overcome by the joint brings the line of the load diagonally through the section downward and outward. Some roads in Europe and in Canada have gone so far as to install rail whose section is such that the web of the rail is built up along this line as a center; in other words, the ball of the rail receives a thrust outward as well as downward and the rail is designed to meet this stress along a line of direct opposition. Manganese steel at the present time adds an impetus much needed. But whatever material is used, the character of the joint must be such that it will withstand the load irrespective of tie tamping as long as the rail holds good.

Illinois. Roadmaster.

Editor, Railway Engineering:

We use continuous joints on main line and angle bars in yards and sidings. Our weather conditions here are not so severe as in some parts of the country, but we try to work our joints spring and fall. We are discarding lock washers for the pressed steel lock nut, and find it satisfactory so far. Our subgrade in this locality is soggy and we are introducing rock ballast as fast as we can get it in. Our section forces work with the extra gang on this and we are bucking rails on the grades on double track and on curves. This takes in the slack on our outside rail and reduces the strain on joint bolts. I cannot say that we have had any special trouble with main joints. Our trouble has been with the ballast and low joints are quite common.

We have only three and one-half miles of double track where we have insulated joints. The Weber insulated joint we use on main line, and wooden splices at fouling point on side track. I keep one man, an old pensioner, on these joints continuously, besides cleaning out beneath the rails. We have very little trouble with the blocked section.

Georgia. Roadmaster.

Editor, Railway Engineering:

There are no insulated joints in this territory. The Weber joint is used to some extent but we have mostly continuous and angle bar. The lock washers are still in service but we are lining up to put in a pressed steel lock nut. We have no extremes of heat or cold. Most of our road in this district is single track and we have very little running rail and no bucking to do.

Alabama. Supervisor.

Editor, Railway Engineering:

Extremes of cold and hot weather are common here. Expansion during the day is quite considerable. We have some continuous joints but very few. There are some Weber joints on a branch line I have on my territory.

Automatic signals are all through this country now on main line. We have angle-bar insulated joints and they give trouble. Some Weber joints are in and they are better. A continuous joint was sent for trial but the drilling was wrong and I had to redrill. This joint pulled apart but I believe it did not have a fair chance, as it was on a floating rail between two sidings with split-point derails. Our ballast is Sherman Hill Granite.

Wyoming. Roadmaster.

Drainage.

Editor, Railway Engineering:

I have had no experience with tile drains, but perhaps your readers would be interested in the method I used in dealing with bad flood conditions at an interlocking plant. The plant in question was in a yard, depressed below street grade of the city. Sewer facilities for street drainage were inadequate so excess rainwater had a habit of accumulating in the yard to a depth of about four inches above top of rail during severe storms. All roads were at their wit's ends to know what to do, as the interlocking plant, being of the electric persuasion, went out of service during and after each flood. During one particularly severe storm I took it upon myself to resort to heroic measures and dug a trench from the point of greatest inflow from the streets to a turntable pit. I managed to swamp the turntable and call down upon my head the execrations of all my superiors, but I saved the plant and, the soil being sandy, the turntable suffered no damage. I was very much interested to see my old trench still in operation a while ago, after a period of two years, so, perhaps, the "men higher up" were not so mad as they seemed.

Illinois. Engineer.

Editor, Railway Engineering:

Speaking of maintenance in general, I had at one time charge of a piece of track that was continually giving trouble, used to heave badly and get out of line. Nothing would hold it. After a while the line was rebuilt, and in digging alongside of the track at the bad spot the steam shovel encountered a tree root of no mean proportions that had run from a considerable distance, so far, in fact, that the tree responsible would, on circumstantial evidence, be entirely above suspicion.

Indiana. Engineer.

Editor, Railway Engineering:

One-half mile west of the terminal in a southern city the road A crosses the road B overhead. This lowers the grade of road B and necessitates a cut of 10 ft. Road B maintains the bridge, and this, together with the cut, which is on a 6 deg. curve and .4 per cent grade, makes a particularly bad place for drainage. During heavy rains, which are frequent, this cut was like a river, rail high, and with no outlet save down the right-of-way to a street crossing, whence it rushed flooding the city sewer at that point and oftentimes backing up into the basements of cotton mills nearby.

After one night's vigil, during an extra heavy rain, I set about to find a solution of the condition. Cinders had been used and tile, but the former merely clogged up the latter. On inspection I found no lower level nearby than through the cut, which proved the natural course for water to flow. On further investigation I found the city had also made a cut for a street which turned at an angle of about 135 degs. at the north abutment of our bridge.

There was a six-foot brick sewer in this street. Fastening a weight on the end of a tape and getting the depth of water level was the work of a few minutes. Then sighting along the top of ties on the bridge to a knot in the right-of-way fence.

and measuring down, gave the height of top of tie on road A above water level in the sewer. A second measurement from the bridge gave me the distance to top of tie on road B. The difference was in favor of the water level in the city sewer; that is, the sewer was 2 ft. 6 ins. approximately below level of cut. A 24-in. sewer pipe with 12-in. iron pipe underneath tracks through 32-ft. cut to 6-in. sewer gave sufficient drainage to cure our troubles and also those of the factories along the right-of-way. Of course, the co-operation of the city engineer's office was necessary, but as it was to the mutual interest of all concerned the city gave consent.

Illinois. Chief Draftsman.

Signal Department.

Report No. 1.

To the International Railway Congress Association. Eighth Session—Berne 1910

(Austria-Hungary, Bulgaria, Denmark, Germany, Luxemburg, Norway, Roumania, Russia, Servia, Sweden, (Switzerland and Turkey)

By Prof. Dr. Ulbricht, Member of the Board of Works, Councilor of the Royal Saxon Treasury.

QUESTION X.

Operation of Switches and Signals.

(continued.)

Now, although there seem to be fundamental differences between installations operated by hand and by power, keeping them quite distinct, there are, nevertheless, signs that intermediate forms may become evolved. When carbonic acid is used, it is already possible to carry out certain operations in connection with hand-operated installations as power operations, by using compressed gas and an electric control. The more recent installations of this kind for individual signals which are a long way off, have given good results. Just as well is it possible, where suitable current is available, to carry out individual operations by electric power and so to relieve mechanically-operated installations in cases where it may be necessary to operate at greater distances than they can be depended on. As stated above, this has already been done on a large scale: at Colmar (Alsace) there is a cabin equipped for the electric operation of signals, with a rod transmission for the switches; this has given satisfactory results for several years now, and appears to act as stimulus to other similar applications.

If to make the work of the signalman easier is the only question involved, the arrangement might be considered of equipping installations operating signals at a distance with power-driven gear, to be set in motion as required, the actual work of operation being done by a small motor. Trials of this kind were formerly made by the Saxon State Railway, but did not lead to any result.

Signals and Switches Generally.

Among the devices which are found both in the case of hand operation and in that of power operation, we may in the first place mention those for ensuring that the signal is in its proper position. The electric checking of the "line clear" and "danger" positions is applied in the case of all power installations, but in that of hand installations only to a very varying extent. Only

In Bavaria, the arrangement is simplified in so far that the incompatible routes can be released by the official controlling the traffic by a blocking field or the main block, after the circuit has been made by special contacts, and the route locking effected for the passing of a train can be cleared by means of a second blocking field. The number of positions of the contacts corresponds to the number of route making fields in the installation. Similar arrangements are also to be found in Baden.

In the case of the group blocking introduced since 1886 in Saxony, there is one common locking gear (generally consisting of two parts) at the apparatus, both for releasing as well as locking during the passage of a train, from incompatible routes; the one part locking in its normal position the signal, the other part intended to keep the routes locked while the train passes.

The current required for releasing a signal only passes to the signal-blocking field, if on the one hand the official managing the traffic connects the conductor for the route in question by means of a special key (consenting contact) with the source of current (station blocking with magneto), and on the other the correct route lever is thrown over in the signal cabin and locked, the corresponding conductor being then automatically connected with the signal blocking field.

The unlocking of the route locking after the train has passed cannot be effected until the signals have been locked electrically at "danger" and requires either the co-operation of the official managing the traffic, at the corresponding contact, or that of the train by means of a rail contact.

The Rank system, which is much used in Austria, is nearly related to the Saxon group locking with consenting contacts. In this system, sliding contacts are used instead of the consenting contacts operated with a key; these contacts are moved on a slide plate arranged like a plan of the tracks, so that the position of the contact at the same time shows clearly that the track in question is occupied.

It is quite intelligible that with such a centralized system of control the safety conditions at a station where the switches and signals are operated singly by hand can be materially improved. The inventor himself, however, by no means proposes this as a full substitute for interlocking installations, but recognizes that these, if dependent also on the official managing the traffic, give the best security against the making of any mistakes.

Electric Interlocking of Route Levers.

The interlocking of route levers is nearly adways effected electrically.

Wurtemberg and Switzerland, however, only use electrical interlocking rarely and chiefly apply mechanical interlocking. In Bavaria also this interlocking is applied in the case of station blocks. The Ssysran-Wjasma Railway has only mechanical route lever interlocking.

In the cases where route levers set to "line clear" are interlocked, the route is often also set by mechanical locking, without any intervention of the electric current in the first place, while an electric current is used for clearing. Continuous-current solenoids are generally used for locking.

Rumania and Denmark use this interlocking exclusively, with mechanical locking and electric clearing.

But departure-route levers are to a great extent interlocked in the same way. The existing exceptions are to be found where sections without block apparatus begin.

The system very generally adopted is that the interlocking of a route is effected by the signalman by a separate operation, an electric current being used; this system owes its adoption to the extensive use of the Siemens & Halske block apparatus. On the other hand, automatic locking when the lever is thrown over is also used in many cases. It has given satisfactory results not only in the case of power-operation, but has also been favorably mentioned in connection with hand-operation.

In all cases where it is necessary to make certain that the switch is not movable while the train passes and the signalman has consequently to lock the route lever in the position corresponding to "line clear," the mechanical or electric interdependence of the route locking and the signal compel the signalman to carry out this operation, before it is possible to set the corresponding signal to "line clear." In

the case of locking the route lever in the final position (position interlocked with the signal) this compulsion generally depends on the interdependence with the official managing the traffic.

In the group blocking adopted in Saxony the route levers are not interlocked in the normal position; consequently, there is no compulsion for any operation of this kind. But, on the other hand, the signal levers are locked in the "danger" position by the previous blocking operation and before release the connections for the route and consequently also the necessary switch movements cannot be made. Consequently the signalman has to close his sections by blocking his signal if he wants to move his switches for shunting operations or in order to make a new route. Thus this blocking replaces the otherwise very unusual locking of the route levers in their normal positions, and at the same time when the section is closed, it forms a necessary condition for the dispatch of unlocking, without which no other train can approach.

In Prussia, in the case of installations where there is section blocking after a train has entered, the signal lever has in the first place to be locked in the "danger" position. This is effected by a double key simultaneously with the blocking of the end field, by which the section behind is open. This blocking of the end field is however only temporary and again cancelled when the route lever brought back into the normal position and then locking the signal, is locked by the blocking. The latter operation, which at the same time releases the unlocking field of the official in charge of the traffic, is thus absolutely compulsory, as until it has been carried out the official cannot give permission for another train to enter, nor can the signal be set to "line clear." Such a compulsion does not exist in Prussia in the case of departure tracks.

In the cases of departures the compulsion for the locking of the route levers in their normal position, and for the simultaneous closing and protection of the section against other departures is more and more effected by the electric interlocking of the signals (for making the signals fly to "danger"), which, when the train passes over rail contacts, makes the signal fly automatically to "danger" and naturally only make it possible to set it to "line clear" after the signal lever has moved back into the "danger" position.

But when the signal lever has been moved into this "danger" position, it is locked in a simple way by a signal lever bolt connected with a locking bar, and this is only released when the signal lever or route lever locking has been completed; so that another train can only be admitted when the different interdependent block operations have been carried out in the proper order.

In principle, there is naturally no objection to the application of such signal coupling devices to entrance or block signals. Up to the present, however, this application has a rule been limited to cases in which sufficient safety was not obtainable by any other method.

As regards the locking gear for hand-operated installations, alternating current is as a rule preferred. Continuous-current interlocking is used exclusively in Wutemberg, chiefly in Denmark, and in some cases by other administrations when the locked route is to be cleared by the trains.

In the case of power installations, continuous current is chiefly used.

The possibility afforded by the electric route interlocking to prevent with certainty any movement of the switches while the train is passing, and that independently of the switchman, is recognized by nearly all the administrations as of much importance from the point of view of safety, and utilized; the locking being effected in the "line clear" position, and the release either by the train itself or from a spot at which it is possible to ascertain that the passage of the train has been completed.

The method and means of release depend on the nature of the locking appliances used (continuous-current or alternating-current installations); it is effected either be means of a special alternating-current unlocking field at the station itself, in which case the official in charge has to attend to the apparatus, or is made dependent on his co-operation, or is effected by the train itself, which unlocks the locking when passing over a rail contact.

The answers of the different managements on the subject of interlocking several route levers by one common appliance show that such appliances are largely adopted, but that there are also very great differences in the construction and action of such appliances.

The most usual arrangement is that every route in it is true locked in the normal position ("route closed") by a separate locking gear, but that for locking in the "line clear" position there is only one common locking gear for each group of routes which mutually exclude each other. Consequently for unlocking this only one unlocking field is necessary, which has to be operated after the train has passed, while for releasing the route levers when in their normal position there are as a rule as many unlocking fields, as there are routes to be considered.

In the case of single-track railways the use, of such group blocking makes it possible to treat the entrances and departures on one side of the station as a group, as they are incompatible, and very simple block arrangements result.

The use of group blocking involves the connection of the route lever bars with contacts, which, as already stated, only make the circuit for the releasing current when the bars have made the proper routes. But sometimes contacts are also placed on the route bars in order to make circuits for the electric interlocking of signal arms and releasing block keys and route locks.

At present but little need has been felt that the electric interlocking of signals or switches should be effected without the action of the route lever. Such appliances are used in a few cases, for instance, in very simple installations. Prussia, however, intends to apply such a system in the case of power installations.

In the cases in which sufficient experience is available, the electrical route-interlocking has, without exception, given favorable results. There is no expression of opinion in its disfavor even in cases of much traffic. Several administrations also speak in favor of mechanical route-interlocking. It is, however, to be noted that Prussia does not intend to use mechanical interlocking in future. Electrical route-interlocking is also strongly recommended in the case of new installations; in some cases attention is also drawn to the fact under circumstances mechanical interlocking may also be advisable.

Measure to Prevent the Premature Operation of Switches.

As a rule pressure or contact treadles are used in order to prevent the operation of the switches taken from the facing side, before the whole of the train has passed. The Austrian North Western and the South Northern have, however, been giving up the use of pressure and contact treadles for this purpose, and prefer switch control locks together with mechanical and electrical route-interlocking. Bavaria has since 1896 been replacing them by electrical appliances.

In Alsace-Lorraine pressure and contact treadles are used at switches also when taken from the trailing side.

Time locks, which lock the switch for a certain time, are as a rule not much used for the purpose mentioned. Experiments made in Saxony and Baden with these appliances have not given favorable results. Owing to the technical and practical difficulties they are no longer used in these countries.

Only in a few instances, but in a number of different shapes, are mechanical devices, such as pressure or contact treadles, used in combination with the electrical appliances. Alsace-Lorraine, for instance, has pressure treadle levers in the continuous-current block apparatus; Saxony has canting rails with electric contacts and Wurtemberg lever locks in combination with insulated rails. In Austria-Hungary and in Switzerland, pressure or contact rails are used together with insulated rails and lever locks, in order to make the operation of a switch impossible before the whole train has passed. The Austrian Southern also uses the so-called contact treadles. Two of these, each 7 metres (23 feet) long, are placed behind each other, or next the two rails so to overlap a little. The electric release of a continuous-current lock, making it possible to operate the signal and unlock the route locking, is only made possible after both treadles have been pressed down simultaneously and have once more resumed their former level.

The proper length of the treadles is generally given as 10 to 12 metres (32 ft. 10 in. to 39 ft. 4 in.). In Saxony there are some 13.5 metres (44 ft. 3½ in.) long, and in Wurtemberg 15 metres (49 ft. 3 in.). The important factor in the settlement of this question is naturally the greatest distance between wheels in regular use.

All the lengths mentioned above have proved satisfactory from the point of view of construction. Some administrations, however, state that they are not yet able to give a definite opinion on the point.

Pressure and contact treadles have as yet only been used on curves by a few German and Austrian administrations, and also in Rumania, and that with good results. According to Prussian experience, the smallest radius admissible is 180 metres (9 chains). It is observed that these require more careful maintenance, as they are very liable to jam if there is any creeping. Rumania remarks that good results with contact treadles are only obtained at curves if placed next the superelevated rail.

In addition to the mechanical appliances mentioned for locking the switch in position till the whole of the train has passed, all the administrations we are considering also extensively use purely-electrical devices.

The most usual of these is the electrical block apparatus for locking the route levers in the normal or in the "line clear" position.

Insulated rails placed before the switch are used for the purpose; while the train is passing over them the switch lever is locked.

Bavaria attains this object in the case of hand-operated installations by fitting a special bolt to each of the corresponding switch levers; this bolt can be operated electrically from the signal box by turning an indicator handle if the insulated rail before the switch is unoccupied. If it is occupied and the signalman should turn the handle, the current would be short-circuited and pass to earth through the axle on the insulated rail and would not reach the bolt. The signalman is informed that a train is passing over the insulated rail or is standing on it by the sounding of an electric bell in the signal cabin. In addition there is an indicator in the form of a small red or white disk showing whether the switch lever is free or is locked.

This arrangement is more recently also used for clearing the routes; with this object in view it is also equipped with a mechanically-acting wheel detector.

In order to arrange matters so that the action of the purely-electrical devices does not terminate before the last axle has passed, insulated rails have been used with good results; instead of them contact treadles can also be used. In other cases the necessary safety against premature operation is obtained by placing the rail contacts at more than a train length from the spot which the whole train has to pass, before it is possible to operate the electric contact gear.

That insulated rails can be used not only for preventing the premature operation of switches and other block apparatus, but can also have important applications for releasing electric arm interlocking, is evident from what has been stated, as insulated rails belong to the class of rail contacts and can be used like them, so as to protect a departing train by making it automatically close the section.

Wurtemberg also uses insulated rails for controlling the departure of trains, the Austrian Southern Railway also for closing an entrance section until the train which has previously entered has departed, also for announcing arrivals and for operating bells when a train approaches.

Switzerland has as yet not used any insulated rails.

The fishing of insulated rails is nearly always effected by wooden fishplates (made of hornbeam or of Australian hardwood), which have given good results. In Saxony, the action of the wooden fishplates is reinforced by the addition of a short longitudinal sleeper made of oak and supported on iron transverse sleepers; this not only adds to the stiffness of the rail at the insulated joint, but also materially helps to prevent any movement of the rail ends relatively to each other.

On the Austrian Southern Railway, good results have also been attained by wooden framing placed under the joint.

When rail contacts are used, the circuits are, as a rule, made as follows: When the train passes on to the rail this is bent and closes a mercury circuit. Experiments have been made recently with the so-called drop contacts of Messrs. Siemens & Halske, in combination with electric block key bolts for intermittent continuous current, and good results have been obtained. As compared with the usual arrangement, this appliance has the advantage that after the rail has once been bent, a number of current impulses are required for interlocking; these are obtained in a very simple manner by the mercury drop contact by the intermittent outflow of the mercury forming the contact. The use of these appliances will be particularly advantageous in the cases where there would otherwise be a possibility of interlocking produced by the action of atmospheric electricity or of stray currents. The co-operation of the train in the safety measures, which results from the use of simple rail contacts, is no doubt a very valuable but not quite perfect method; but there is no doubt that it is much improved from the point of view of safety by the automatic production of intermittent current.

As the above shows, insulated rails and rail contacts are principally used for locking and unlocking levers and other block apparatus in the cabin; sometimes there are also used, as in Wurtemberg, Denmark and Russia, for warning the signalman. Other similar applications are also made in individual cases.

It seems more especially very natural that such appliances should be used in order to announce automatically the approach of a train at a level crossing where there is a fair amount of traffic, so that the gates may only be closed a short time before the train arrives. It is also desirable that a train should automatically give notice of its approach, so that any necessary precautions may be taken, at level crossings without gate keepers on secondary lines; also at places where the line leaves a tunnel, or goes over an iron bridge, and a busy street is alongside, where horses may easily be terrified by the sudden appearance or the noise of the train. But all these methods of announcement have unfortunately the disadvantage, that their failure does not notify itself and may consequently give rise to misunderstandings resulting in serious accidents. The advantage obtained in the one way is counterbalanced by the serious extra responsibility resting on the maintenance staff. It is accordingly intelligible that there is a certain hesitation in adopting such methods.

As regards the prevention of the premature operation of switches, besides rail contacts, insulated rails and treadles, there are also some simple mechanical devices in use. Thus the Austrian North Western and the South Northern use switch control levers for this purpose, depending on the mechanical and electrical route interlocking gear; such control locks with portable keys have also given very good results in many other cases for obtaining relations in simple switch and signal installations and for combinations of switches and switch blocks.

The electrical devices used in Bavaria instead of pressure and contact treadles, especially the much-used lever locks, have already been referred to.

It is a nearly-generally accepted opinion that it is desirable that all switches taken from the facing side should be fitted with devices to prevent the premature operation of the switch. There are only a few admistrations who consider that it is sufficient if such devices are limited to those cases, in which the switch cannot be properly seen from the cabin and has to be operated immediately after the train has passed.

There is but little need to extend the use of these devices to switches which are taken from the trailing side. This as a rule only has to be considered in the case of switches which are at a great distance or cannot be seen from the cabin and are much used for shunting operations.

No particular difficulties in the service or in maintenance have arisen from the use of these safety appliances for preventing the premature operation of switches. The general opinion on the contrary is that they have a favorable influence on the carrying out of the service.

An unfavorable opinion is however expressed in several cases as regards time locks. The St. Gothard Railway does not consider them suitable for stations at which much shunting work takes place. In Rumania also they did not in all cases give favorable results. It has already been mentioned that in Saxony and Baden technical and maintenance difficulties arose in connection with the time locks, and therefore their use was given up.

Nevertheless they are a simple and valuable auxiliary for the locking of solitary switches; several administrations will in the future use them as well as pressure and contact treadles and insulated rails. When several switches however have to be locked for one given train, the preference is as a rule to electric route-interlocking.

Alsace-Lorraine prefers the insulated rail with added rail contact connected with a continuous-current blocking field on the locking of a block key. The Austrian Southern considers that the best to use at large stations with block system are electro-mechanical treadle rails; at smaller stations, pressure treadles; and at switches not otherwise protected, Schilhan treadle rails.

Denmark, Sweden and Switzerland do not speak in favor of any definite system, partly because enough experience is not yet available.

Graphic Representation of the Occupation of Platform Tracks.

In order to facilitate the management of traffic at very busy stations, some of the Prussian administrations use graphic representations, in which the occupation of the tracks is marked in advance in accordance with the time-tables.

The traffic and maintenance offices in Saxony use such representations in the form of plans showing the operation of the traffic only in order to be able to judge the effect of proposed alterations in the operation of the traffic or in the arrangement of the tracks. Such representations are not used in Bavaria. Baden and on the Swiss Federal Railway, but on the other hand there are appliances provided (block relations, order of route levers) at the chief apparatus or at the cabin which, when a train is there, close the entrance to the track in question until that train has taken its departure and the occupied or unoccupied condition of the track is notified in the cabin by colored disks.

Wurtemberg, in order to show the occupation of the tracks, only uses indicating plates.

In cases of the latter kind the occupation marks are movable, while in the former they are not. A simple method of graphically representing the occupation of the tracks by means of movable marks is as a rule available in the case where the separate lines or routes are made by the official managing the traffic by operating blocking fields or contact devices, in which the locked or unlocked condition of each separate route is indicated by colored disks appearing behind small windows in the signaling apparatus.

These signal windows are as a rule arranged in the same order as the corresponding rails, so that the state of occupation is easily grasped. This system of graphical representation is particularly developed in the Rank block apparatus which has already been mentioned in which the releasing contacts are closed by buttons, which can be moved along the lines on a diagrammatic plan of the station, which represent the tracks.

In the case of the appliances commonly used in Bavaria and Baden and on the Swiss Federal Railway the change of the colored disks, showing the occupation of the tracks, is effected when the route lever at the station or signal cabin is operated.

An electric check to show that the signal lanterns are alight is generally dispensed with; it also does not appear to be taken into consideration for the future, to judge from the results obtained. Only in cases where electric signal lights are used (tunnel signals in Switzerland; a few signal lights on the Russian State Railway and a switch section signal in Saxony), is a check provided by a control lamp in the same circuit.

The ordinary illuminating power of the signal lanterns, as a rule, appears to suffice. Attempts to improve the illuminating power have only been made in Baden (by increasing the size of the reflectors), in Saxony (by unsymmetrical arrangement of the reflectors for the front and back light), and on the St. Gothard Railway (by increasing the size of the burners). Electric lighting has been applied to a number of signals with considerable success. Trials of acetylene lighting did not give satisfactory results.

In some districts liable to fog, the effect of the signals is reinforced by repeating the lights at definite intervals. A yellow double light has been introduced in Germany since 1901 on several large experimental sections (extending altogether to over 200 kilometres—124 miles), as a "caution" distant signal; this light shows up much better than the other colored lights because the amber-yellow glass absorbs very little light. It will probably be introduced in the whole of Germany for distant signals. The yellow distant signals are also used in Denmark.

All administrations are striving to prevent the fracture of the signal-light glasses. The chief measures adopted are wire glass, as well as an elastic setting or one which gives a little, such as tin, leather, lead, etc. It is also important to reduce any shock resulting from the impact of the mass of the signal; counterweights and spring stops are used for the purpose. Some administrations consider wire glass very useful; in other cases (Swiss Federal Railway), it is considered unsatisfactory. It is true that it cannot readily break into pieces, but it easily becomes cracked and crumbles, so that part of the white light passes through.

The possibility of the hand-operation of switches on the spot, in cases of failure, is everywhere provided for; in the case of electric motors frequently only by the provision of an auxiliary cranked handle; in this case, the operation takes a comparatively long time. In the case of hand and power-operation, the lever which is there ready, is fitted into the gear and connected with the switch without difficulty. On the Saxon State Railway, the hand levers are left permanently in place, and, as a rule, they are only kept disconnected.

Particular conditions exist in districts where spring switches are used; the blades of these switches can only be moved into the other position by overcoming their elastic force, which is not inconsiderable. This elastic force amounts to about 50 kilograms (110 lbs.), and acts at the blade not in contact in the direction opposed to the movement produced when the switch is cut open. Thus theoretically it is to some extent in contradiction with the cuttableness of the switch. As, however, this force of 50 kilograms (110 lbs.) only comes into play to a materially smaller extent and as on the other hand the forcing open of the lever interlocking in the cabin, when the switch is cut open, requires a force of about 200 kilograms (440 lbs.) acting on the transmitting parts, there remains in the case of spring switches an ample margin of resistance against the cutting open. Nevertheless, provision is made in the case of electric operation to increase the resistance to movement of the blades in their final position by adding a spring friction catch, so that from this point of view there is nothing against extending the use of spring switches. In the case of compressed-air operation, no particular devices at spring switches are necessary, as the pressure behind the piston overcomes the resistance of the blade readily. Up till now, within the limits of the countries we are considering, it is only in Germany and Austria-Hungary that spring switches set from a distance are used, in most cases experimentally. It is, however, to be expected that their use will become extended, as they present advantages not only from the point of view of smooth running, but also from that of maintenance, and prevent any longitudinal movement of the blade relatively to the stock rail; and this is particularly desirable when points with the blade and stock rail clamped together are used.

Besides signals and switches, barriers and level-crossing gates are also frequently operated from the cabins. Both can be included in the route interlocking, so that the corresponding signal cannot be set to "line clear" until they are in the proper position for that purpose. But nearly everywhere, only the barriers have been included, while the level-crossing gates are only operated from the cabin, but not interlocked with the route mechanism, in order not to stop the street traffic the whole time the block continues. This relief to the street traffic, however, results in increased responsibility for the signalman. The uniform practice of the majority of the administrations shows that this is, however, considered the lesser disadvantage.

A material improvement in the value of the safety appliances has been effected by making the train co-operate. This makes it possible, by the use of treadles and rail contacts, to make any operations in the cabin dependent on the condition that the train has passed a given spot or has left a given section of road. This is effected by having electric block fields in the signal box, or by electric interlocking with the signals, unlocked by the train; the latter is more particularly the case at the beginning of block sections. Devices of this sort have been very largely introduced not only in the case of power operation, but also that of hand operation.

It is true that rail contacts are also used to notify of the approach of a train, but only in a few solitary cases.

One of the most important questions in railway working has always been, how cases of the over-running of signals can be prevented, reduced or made harmless. Distant signals and detonators give valuable results in this connection, but they cannot absolutely prevent the men on the locomotive from over-running a signal if there is thick weather, if the signal light has become extinguished, or if any occurrence strongly attracts their attention. Detonators, if powerful, are bound to be noticed by the driver even under unfavorable conditions; as a rule, they are used only in cases of fog or if a section has unexpectedly to be blocked, and thus in many cases the possibility of the danger mentioned continues to exist. Consequently, in some cases, alarms or gongs have been added in the distant signals; these continue to sound, when the train passes, if the signal is set at "danger." But it has also been considered desirable to have some means of drawing attention to the spot where the distant signal is located, without putting an extra load on its wire transmission by a second device which has to be operated. Among such are, besides the strengthening of the illuminating power of the signal lights and having several lights, as already mentioned, also the large marks at the distant signals, made of sleepers and used in Prussia, and the sound-reflecting walls, now being tried, which are to attract the attention of the locomotive driver by reflecting the noise made by the trains, as in passing under bridges. Electric and pneumatic horns which are automatically started by the trains, have also been tried at distant signals for the same purpose. These devices have not, however, been introduced to any large extent, and have mostly not passed the stage of long experimental trials, except in the case of the large marks at the distant signals, which are very satisfactory in a limited way, but cannot be considered to be a very powerfully acting accessory.

Then, also, many inventors have for tens of years aimed at making a warning signal appear or sound in the locomotive cab when the train approaches a main signal standing at "danger." But only few of the devices proposed have proved at all promising. In the countries we are considering, matters in this respect have as yet only reached the experimental stage. The chief difficulty is that the electric-contact devices for conducting the current from the line to the locomotive (such as the Lartigue "crocodile" contacts) cannot be depended on to act satisfactorily under unfavorable climatic conditions, as extended trials made by the Saxon State Railway on a line in the Erzgebirge have shown; and that mechanical devices are not only very liable to destruction in consequence of the high speed of trains, but also exercise a bad influence on the reliable working of the distant signal, if connected with it. Nevertheless, several experiments have recently been begun in Germany with the van Braam signaling system, in which a treadle on the line acting on a sensitive lever with a transmission to the cab, fitted to the locomotive, operates a powerful signal, records the operation and if required also applies the continuous brakes. The latter seems at first sight a desirable action from the point of view of safety; but weighty objections have been raised against it.

Attempts are also made to obtain a certain amount of protection against the over-running of signals by having every case of over-running, even if it has not been attended by any detrimental consequences, recorded by an automatic recording gear; and afterwards the driver is held responsible. This is effected on different stations in Prussia by a recording counter fixed in the office of the traffic manager, which is operated by means of a rail contact each time a signal is over-run. At the same time an alarm is released, which draws attention to each individual instance, so that these can then be properly recorded in a book.

The extreme measure to meet danger from the over-running of signals is to turn the train into a side track, on which the train can run itself out or is stopped by sand (Kopcke's sand tracks); this is adopted by several administrations, in suitable places. On the other hand, on dead-ended tracks where only a small distance is available for the braking, sand is placed with hydraulic buffer stops at the end, in order to stop a train should it have come in too quickly. As a result of extended experiment, Saxony is lately considering the use of skids, which oppose to the pushing action of a train a considerable frictional resistance, reinforced by springs, designed for a length of stop of about 30 metres (33 yards).

A special system of signaling has in a few cases become developed at advanced entrance signals, at which trains have sometimes to wait a long time. The German regulations specify that in this case the locomotive driver should receive the order "wait." If this order cannot be given by an employe by means of a horn signal, an electric trumpet or syren is successfully

used; this is placed near the entrance signal and operated from the station and signals "wait" by the Morse code, a series of short and long sounds being given.

The setting of a signal to "line clear" is nearly generally made dependent on the co-operation of the traffic manager, by means of electric, or more rarely of mechanical unblocking devices, or by means of contacts which have to be made before the signal can be operated.

Very good results have been given, in the case of a shunting service, in order to communicate between the top of the inclines and the switches at the corresponding sorting sidings, by loud-speaking telephones as well as by electric track indicators, which are constructed on the pattern of needle telegraphs. Track indicators which have incandescent lamps lighting up behind transparent number plates have also been used with advantage.

Mechanical needle instruments with a wire transmission have also been used instead of the electrical instruments. In many cases, however, for instance in Switzerland, the siding numbers are only written on the buffers of the descending wagons; in Bavaria, numbered plates are hung on the buffers.

Newer installations and arrangements are devised with the object of making it unnecessary to give individual indications in the case of each descending wagon as in accordance with American practice the order of sequence of the different sidings on to which the wagons are to run is laid down in advance in writing, so that the switches can be set in succession in accordance with this list. A further step in advance is the use of power installations to carry out the sorting operations required; in the system devised by Messrs. Siemens & Halske, a paper band, perforated to correspond to the list, regulates the sorting automatically.

Any further improvements in connection with switching and signaling appliances are not contemplated by the different administrations.

In connection with this discussion of switching and signaling appliances, we would mention a system intended, where traffic conditions are simple and where expenditure is to be avoided, to serve to some extent as a substitute for the necessary mechanical or electrical relation between the position of the signals, the position of the switches and the running of the trains.

The Russian Polessia State Railway has installed at seven of its stations an electric system for the control of the signals and switches, devised by its telegraph superintendent, Oberst von Fiedler, and called "Phono-Indicator." This enables the official controlling the traffic to send orders to the switchmen and the signalman to set the switches and the signals for a train, and also to see at any given moment in what position the switches and signals are.

While the switch is being operated, a trembling bell continues to sound until the switch blade is right home. A similar bell at once attracts the attention of the man in charge if by mistake he sets an entrance signal to "line clear," when the corresponding switches are in a wrong position.

This warning signal also sounds if two incompatible signal operations are carried out simultaneously.

The chief constituent part of the arrangement is an accurately working switch contact, not affected by the weather. Any faults in the circuit are automatically announced by the bell. In addition to the electric ordering and controlling apparatus there is also telephonic communication between the station official and the switchman.

An extended controlling system, the centralized phono-indicator, has been developed for stations with more than three tracks; this is designed so as to satisfy all the requirements of a good centralized installation, with the sole exception of the interdependence produced by interlocking.

Any system of effecting the movement of the marks indicating the occupation of the tracks from the outside, such as automatic adjustment produced by the movement of the train on the tracks in question, does not seem to be in use anywhere, but on the other hand the setting of the marks often has a restraining or permissive effect on the signal apparatus.

We may also include here the automatic electric device of Messrs. Siemens & Halske, in which the succession of the shunting operations is marked on a strip of paper by means of punched holes, and is then automatically carried out by the apparatus.

Other relations between the graphic representations and the train movements and the occupation of the track concerned have as yet not been effected.

The graphic representations of the occupation of the track, mentioned above, are by no means limited to platform tracks; they are also frequently extended, in so far as they are used at all, to other entrance and departure tracks. This applies especially if we also include among them the marks appearing in the case of electric unlocking appliances. With this extended meaning attached, it also applies in some cases to locomotives running light, while graphic representations proper, of the occupation of the track, are not used in these cases and in the case of shunting operations.

The arrangements mentioned are stated to give good results both as regards the facilitation of the service and as regards safety. The use of graphic representations has proved especially valuable when special trains have to be intercalated.

In organizing the train service at a large station, as far as the point of view of safety is concerned, the importance of such graphic representations is small as compared with the further development of electrical checking devices and means of communication, which make it possible for the different apparatus to work separately and yet form one united whole from the point of view of safety.

CONCLUSIONS.

The chief conclusions to be drawn from the answers and information concerning question X received, are as follows:

Hand-Operation.

1. The newer developments in the methods of operating switches from a distance have extended more especially in the direction of double-wire transmissions, and have resulted in appliances giving results which are satisfactory from the point of view of safety, although still capable of improvement; there is therefore no reason for departing from this direction.

2. The operation of switches by means of rod transmissions is preferred to a smaller extent, in some cases only under special local conditions; such transmissions are less liable to fracture, but any fracture is not controlled automatically as easily as in the case of double-wire transmissions.

3. The operation of switches at a distance should also be combined with locking (switch bolts, blade locking), or should be made safe by separate subsequent locking (control locking).

4. In the case of important switches taken from the facinging side, whether the transmission be by rod or by double wire, it is in many cases considered necessary to have control locking in addition to the locking of the cabin apparatus.

5. The use of reacting cuttable switch locks with separate operation of the switch blades has given good results. The most usual way of securing the blade is by a thrust obtained from a special point of support, but switch locks in which the blade and stock rail are clamped together are now used more extensively.

6. Switching gear with wire transmissions have for many years given good results, both those which include gravity stretchers and those which do not; but the addition of gravity stretchers makes further control and automatic blocking

possible. The required degree of reliability of the switching gear is obtained by protective casings, by a suitable size of the weights and a suitable height of drop.

7. The locking of switches is only applied to a limited extent, apart from the control locking switches which are far off.

8. Double-wire transmissions are exclusively used for the operation of signals at a distance.

9. The intercalation of control locks in the wire transmissions of signals is not quite without influence on the certainty of the operation; nevertheless it is frequently used in order to simplify the installations.

10. For the same reason, the operation of the distant and of the main signal is also frequently effected by one double-wire transmission only. Operation by two double-wire transmissions with separate interlocked levers, is more certain and hence preferred by sundry administrations.

11. It is absolutely necessary that the fracture of the signal wire transmission should result in the signal being at "danger." Where gravity stretchers are used at all, they are generally also used to assist in producing this result.

12. The use of ball bearings and roller bearings in switch and particularly in signal installations has proved advantageous, but as yet they are used only to a limited extent.

13. Electric signal arm interlocking has proved a valuable auxiliary in the case of mechanical installations.

14. Improvements in hand-operated installations are attainable and are to be expected, in reducing frictional resistances, in giving better protection against disturbing outside influences, in improving automatic controlling, locking and blocking appliances, as well as in the further addition of electric auxiliary appliances.

Power-Operation.

15. Only electricity and compressed air with electrical control have given promising results as sources of power for the operation of large installations.

16. In individual cases good results have also been obtained by ocmpressed carbonic acid, with electrical control.

17. Up to the present the number of failures is greater in the case of power-operated installations than in that of hand-operated installations. The former still want special expert maintenance and the capital outlay is greater than with the latter.

But with power installations a large amount of traffic can be dealt with more quickly than with hand installations; a number of safety conditions when operations are carried out at a distance can be satisfied better with the former than with the latter; in many cases the former also results in a saving of staff.

18. Their further extension at suitable places, especially in the case of new installations at stations with much traffic, is contemplated by those administrations who have tried them on a larger scale. The further development of such systems of power operation can therefore be looked upon as certain.

19. As regards the railways we are here considering, more experience is available about electric installations than about pneumatic. The question which of the two sources of power, electricity or compressed air, is to be definitely preferred, is as yet undecided.

20. Combination of hand-operated and power-operated appliances in one apparatus has been tried with fair success.

21. The simultaneous operation of the switches of a whole route, possibly in power installations, is not effected and one limits oneself to operating each switch separately or operating two related switches simultaneously.

22. The electrical installations are operated with continuous current exclusively, but the question of operating with single-phase or three-phase current is under consideration.

Signals and Switches Generally.

23. The control of the completion of the operation of a signal at a distance is generally limited to the control of the "danger" and "line clear" positions. But there are also in use controlling devices with special checking for any doubtful intermediate positions.

24. The electric control of the position of the signal is as a rule not extended to distant signals, although these, from the point of view of their importance, have as a rule not less need for control than the main signals.

25. Spring switches can be set at a distance, in cases of hand-operation as well as power-operation, with as much certainty as ordinary switches.

26. The setting of barriers at a distance is often included in the route interlocking, that of level-crossing gates seldom.

27. The action of the train on the apparatus, by means of rail contacts and insulated rails, has given good results; this system has been applied extensively.

28. On the other hand, devices to enable the cabin to act on the train, so that a rail contact or treadle will produce a signal in the cab or will apply the continuous brake, are still in the experimental stage.

29. Opinions are divided on the question, whether it is desirable to apply the brakes in this way from outside.

30. Several administrations use sand tracks, the switches of which are operated from the cabin.

31. Electric track indicators have been successfully used for indicating the tracks at gravity sidings.

32. It has been proposed to set the switches automatically at gravity sidings with electrical operation.

Electric Interlocking of Route Levers.

33. The electric interlocking of route levers (locking with electrical release) is very much preferred to purely-mechanical locking and unlocking.

34. The route interlocking is as a rule made dependent on other operations on the cabin in such a way that its operation is compulsory.

The co-operation of the train by means of rail contacts is utilized in this connection with advantage.

35. Electric interlocking gear works in most cases very satisfactorily with alternating current.

36. The locking of several routes by one single appliance (group locking) has been introduced in several stages of development and has given good results.

Prevention of the Premature Operation of Switches.

37. The locking in position of a switch while a train passes, so as to prevent its premature operation by the signalman, is generally recognized to be desirable. This safety measure is most important in the case of switches taken from the facing side.

38. Pressure or contact treadles, partly combined with electrical appliances, are extensively used for this purpose, and with good results; time locks are used less, and some administrations object to these as unfavorable results were obtained with them.

39. Safety measures consisting of electrical appliances only (unlocking gear, rail contacts, insulated rails combined with electric lever locks) are used extensively for this purpose, and with success.

40. Reliable devices have been worked out for the fish-joints at the ends of insulated rails; in some cases they are combined with extra supports.

41. Where there is little traffic and only a small number of switches, good results are obtained by using control locks at the switches for locking them in position, with portable keys.

Graphic Representation of the Occupation of Tracks.

42. Graphic representations of the occupation of tracks are, as a rule, not limited to platform tracks, but are generally also extended, the form of plans of the traffic operation,

to other entrance or departure tracks, the occupation of which is determined in advance in accordance with the timetable. They have proved particularly useful for the intercalation of special trains.

43. At some stations the occupation of the different tracks is shown at the office of the official managing the traffic by removable indicator plates. The marks appearing at the signal windows of the block apparatus also form, in a sense, a graphic representation of the occupation of the tracks.

Railway Signal Standards No. 8. The Boston & Albany.

Signals are operated by storage battery, charged from line or by potash primary battery, 5 cells of the former or 16 of the latter are used for one signal. The line circuits are fed from a separate battery, usually gravity. Common wire is broken at least every five miles.

Primary operating battery is housed in concrete battery wells, Fig. 187: note the clamp for holding trunking in place. Storage battery is housed in boxes, concrete or wooden, Fig. 188. A similar box is used for storage track battery, but is made smaller. Gravity or storage battery is used for track circuits. Where gravity is used there are two or three cells per section housed in an iron chute, if a well is not available. Single chutes are similar to that shown in Fig. 47. Fig. 189 shows a double chute for holding two elevators. Cells are connected in an elevator as shown in Fig. 190. A charging station is shown in Fig. 191.

Typical arrangements of apparatus on the ground are illustrated in Figs. 192, 193, 194, which show also method of grading. Signal foundations are shown in Figs. 195, 196.

A separate pole line for signal circuits is not used. Wires for the various circuits are arranged as in Fig. 197. Taps to line wires are made as in Figs. 198, 199, and ties as in Fig. 200. Fig. 201 shows method of double arming and Fig. 202 method of back bracing. Where it is necessary to change from line wire to cable it is done as shown in Fig. 203. Cables are run from line to a stub pole as shown in Fig. 204, and a cable post with junction box in Fig. 205. A small wooden relay or junction box appears in Fig. 206 and a large one for four relays in Fig. 207.

Wire ducts are run above ground and are made of wooden trunking. Bootlegs are made and applied as shown in Fig. 208. Fig. 209 shows how frogs are bonded. The angle bar type of insulated joint is used. Typical circuits for normal clear, two position signals are shown in Fig. 210 and for normal danger three position signals in Fig. 211. Note the low voltage line control with 16 ohm relays. In Fig. 211 also is shown method of controlling semi-automatic power operated signals. Typical circuits for the control of a power operated distant signal with a mechanical, slotted home signal are shown in Fig. 212, and for a slotted mechanical home signal in Fig. 213.

Fig. 214 is a diagram of aspects of three position, upper quadrant signals under varying conditions of track occupancy. The average length of a block is 4,400 ft., and single track circuits of this length are not unusual. Overlaps are not used on double track in new installations, neither are switch indicators. Track relays have resistances of 4 to 16 ohms. All relays are of the wall bracket type, enclosed.

The following sizes and types of wire are standard: For line, No. 10, B. & S. gage hard-drawn copper, No. 10, B. W. G. galvanized iron and No. 12 B. & S. gage copper clad steel, all with weatherproof insulation. For bootlegs, leads from track and leads from battery, No. 10 B. & S. gage rubber covered copper. For leads from line to apparatus No. 14 B. & S. gage rubber covered copper.

F. W. Alexander has been appointed assistant division engineer of the Canadian Pacific, with offices at Calgary, Alberta, succeeding T. Martin, promoted.

T. H. Haggerty has been appointed smoke inspector on the Chicago terminal division of the Chicago, Rock Island & Pacific, with office at Chicago, succeeding E. A. Lutzow, resigned.

F. I. Cabell, engineer maintenance of way of the Chesapeake & Ohio at Richmond, Va., has been appointed also chief engineer maintenance of way of the Chesapeake & Ohio of Indiana, with office at Richmond.

J. S. Berry, superintendent of bridges and buildings of the St. Louis Southwestern at Tyler, Tex., has been transferred to St. Louis, Mo. William Quinn, master carpenter at Tyler, succeeds Mr. Berry, in charge of the Texas lines of the company.

G. E. Ellis, formerly signal engineer of the Chicago, Rock Island & Pacific at Chicago and recently connected with the Federal Signal Company, has been appointed signal engineer of the Kansas City Terminal Railway, with office at Kansas City, Mo.

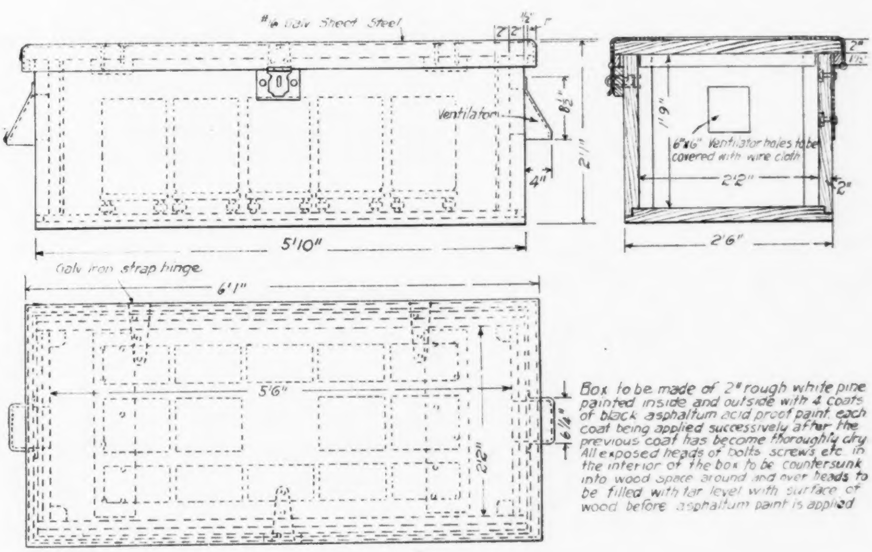


Fig. 188. Wooden Battery Box, Boston & Albany.

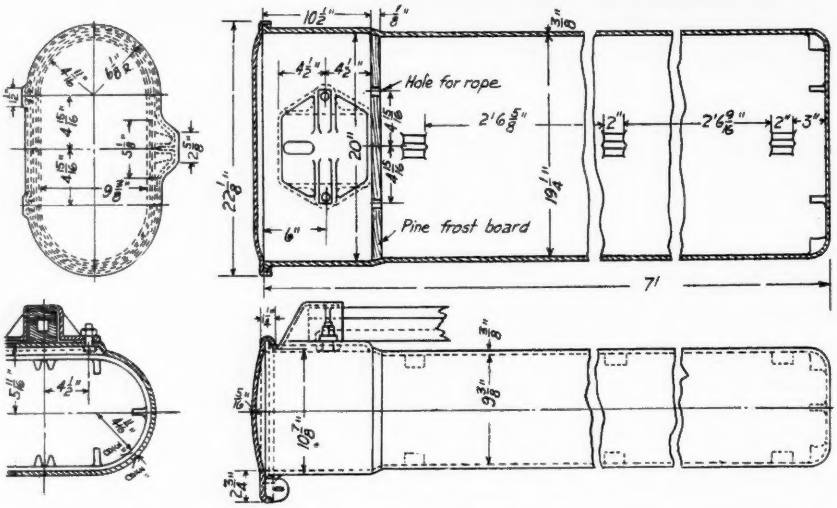


Fig. 189. Double Cast Iron Battery Chute, Boston & Albany.

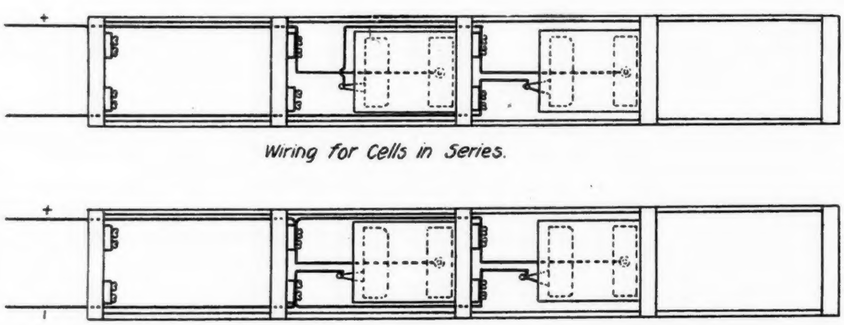


Fig. 190. Wiring of Gravity Cells in Elevator, Boston & Albany.

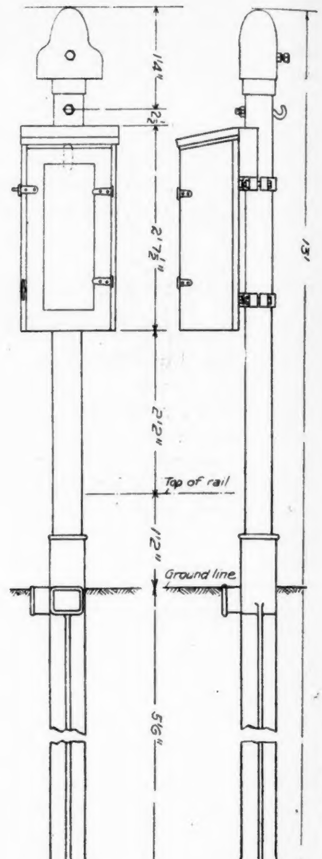


Fig. 205. Cable Post and Junction Box, Boston & Albany.

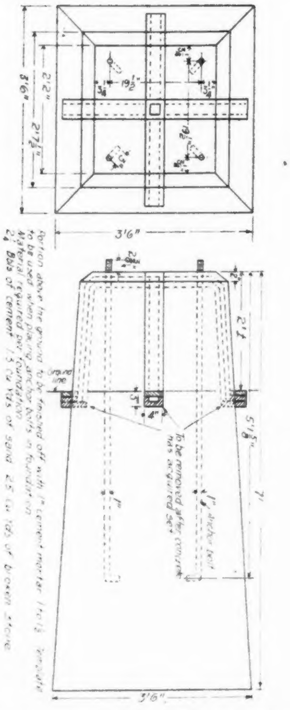


Fig. 195. Signal Foundation, Boston & Albany.

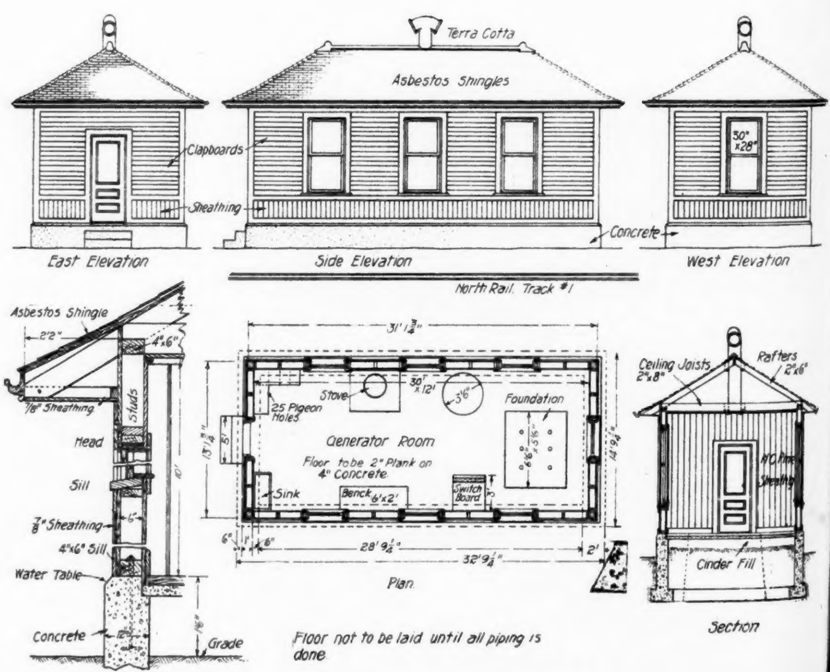


Fig. 191. Charging Station, Boston & Albany.

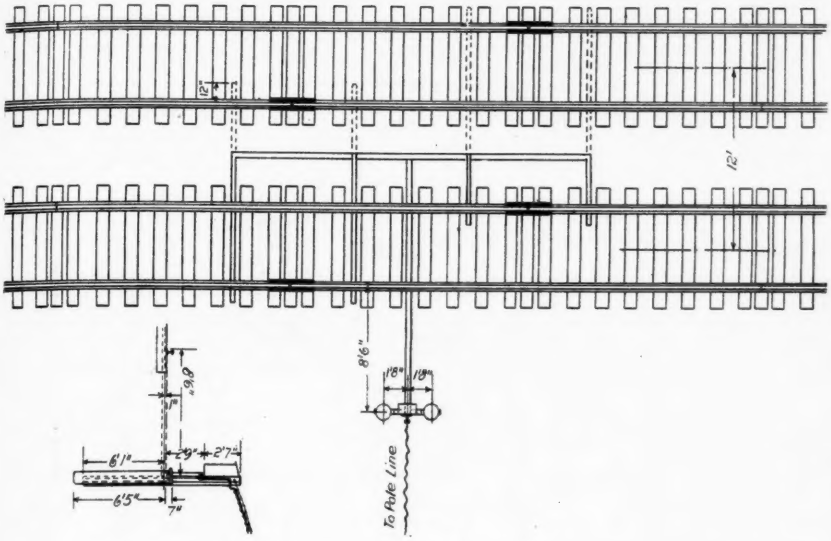


Fig. 192. Arrangement of Apparatus at Cut Section, Boston & Albany.

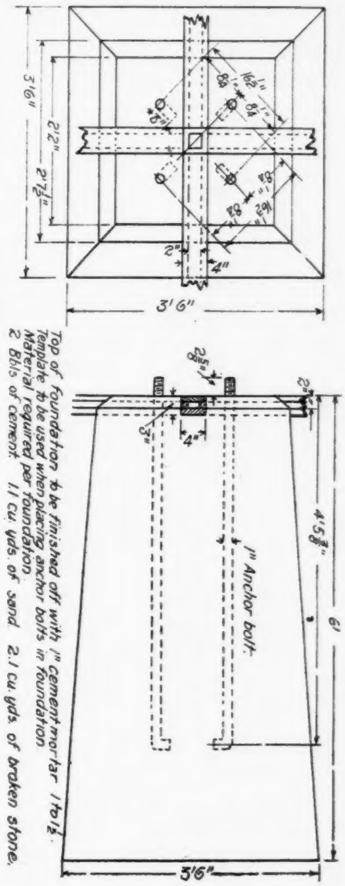


Fig. 196. Signal Foundation, Boston & Albany.

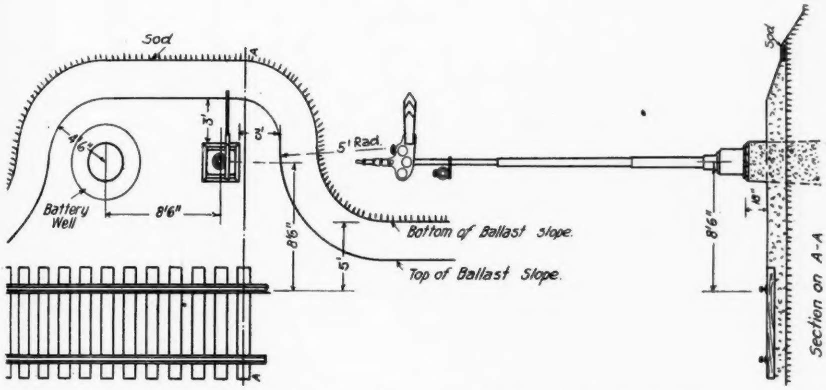


Fig. 193. Arrangement of Apparatus at Signal Location, Boston & Albany.

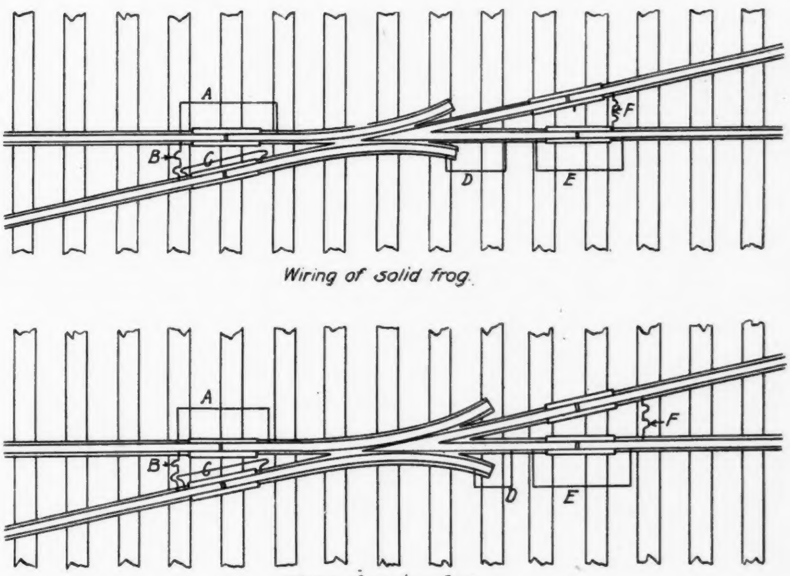


Fig. 209. Bonding of Frogs, Boston & Albany.

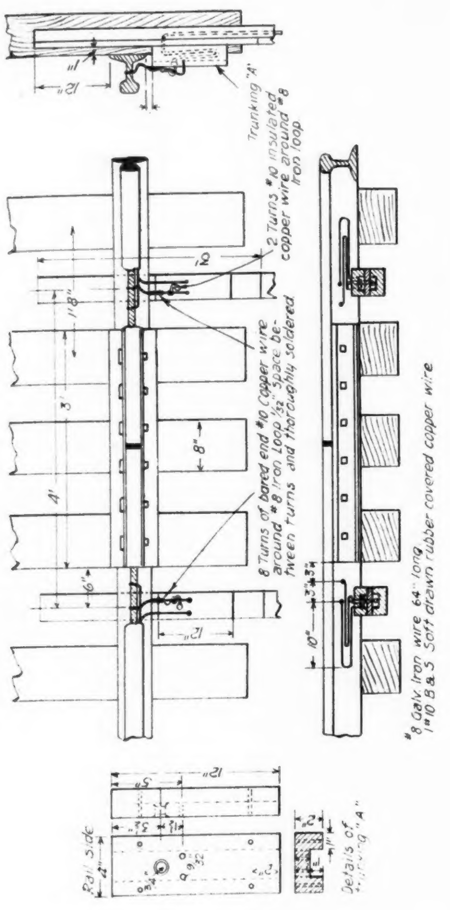


Fig. 208. Bootleg and Application, Boston & Albany.

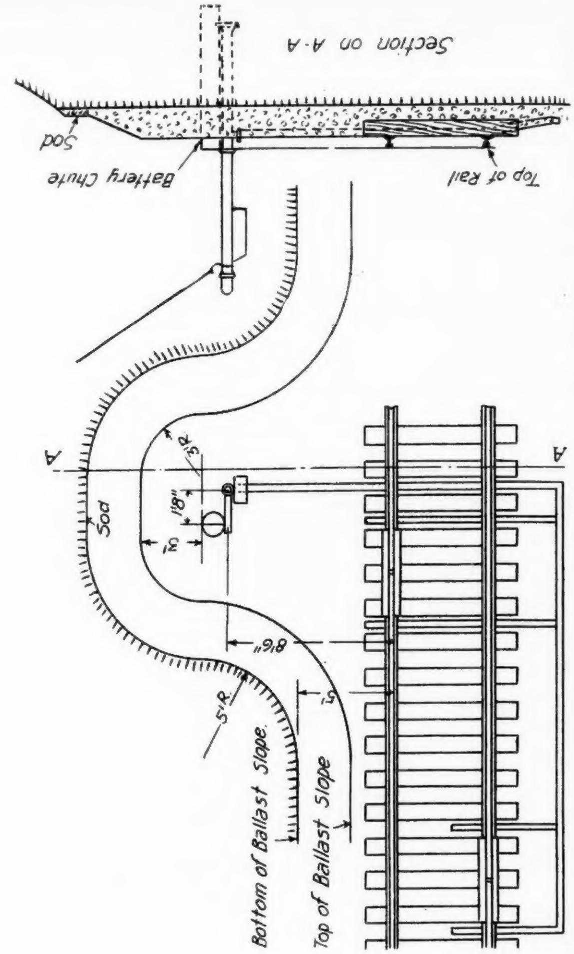


Fig. 194. Arrangement of Apparatus at Cut Section, Boston & Albany.

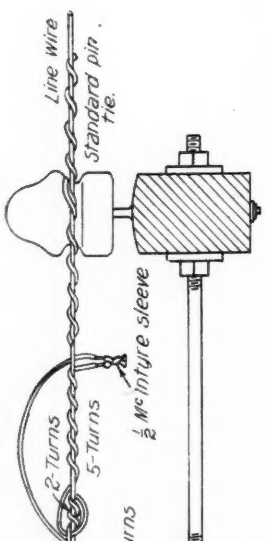


Fig. 198. Taps to Line Wires, Boston & Albany.

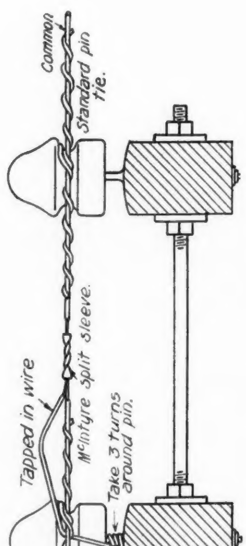


Fig. 199. Tap to Common Line Wire, Boston & Albany.

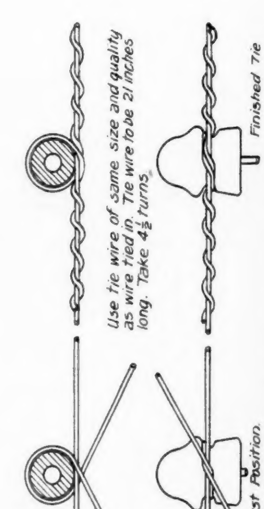


Fig. 200. Line Wire Ties, Boston & Albany.

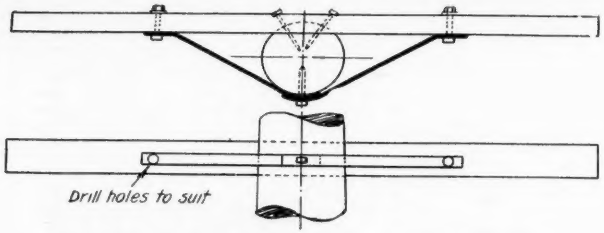


Fig. 202. Method of Back Bracing, Boston & Albany.

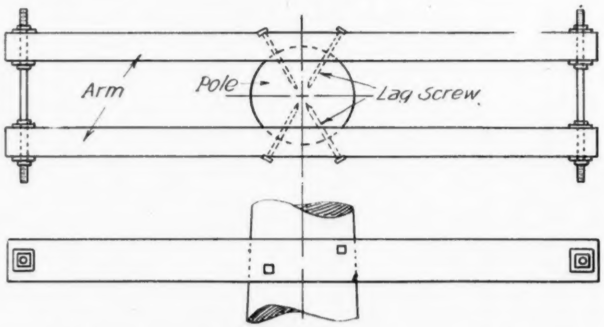


Fig. 201. Method of Double Arming, Boston & Albany.

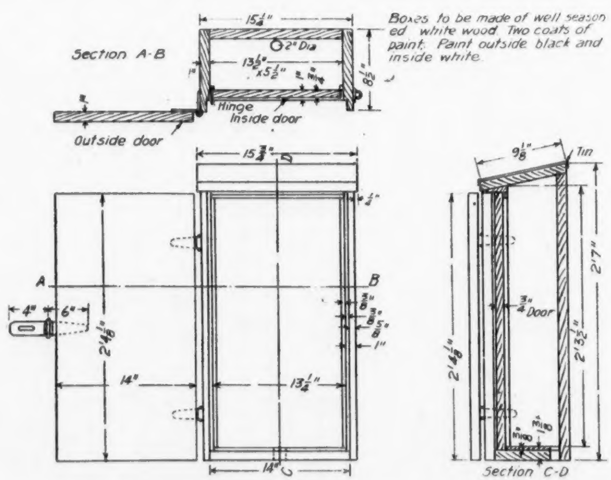


Fig. 206. Small Relay Box, Boston & Albany.

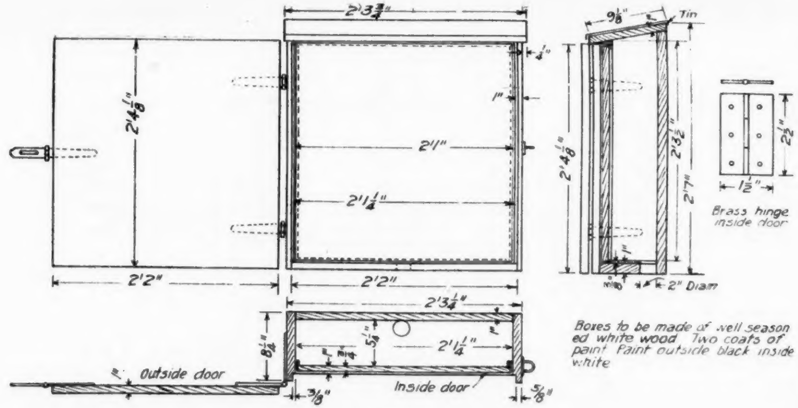
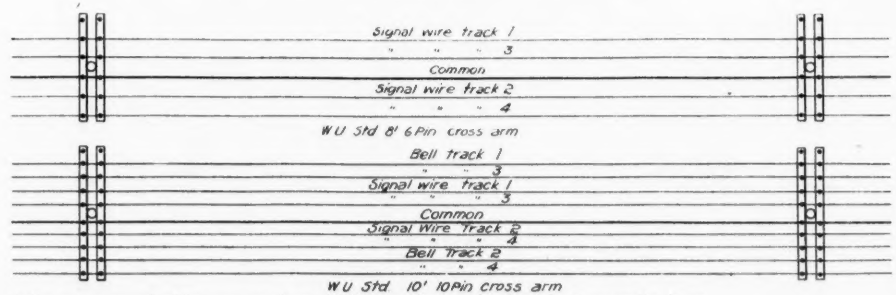


Fig. 207. Large Relay Box, Boston & Albany.



In the arrangement of line wire as shown it is the prevailing practice to string same on the lower arm of W.U poles. This arm is known as the Signal Department's cross arm. The exceptions to the above being when the conditions prevent the locating of W U poles in close proximity to the Railroad Co's Right of Way. In such cases a free and independent pole line is run and same known as Railroad Co's property. Common wire is always run where possible on the polepin on the track side of pole line.

Fig. 197. Arrangement of Line Wires, Boston & Albany.

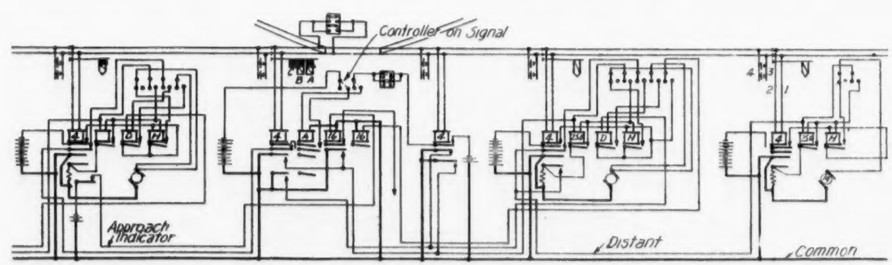


Fig. 211-A. Method of Controlling Semi-automatic Three-position Signals, Boston & Albany.

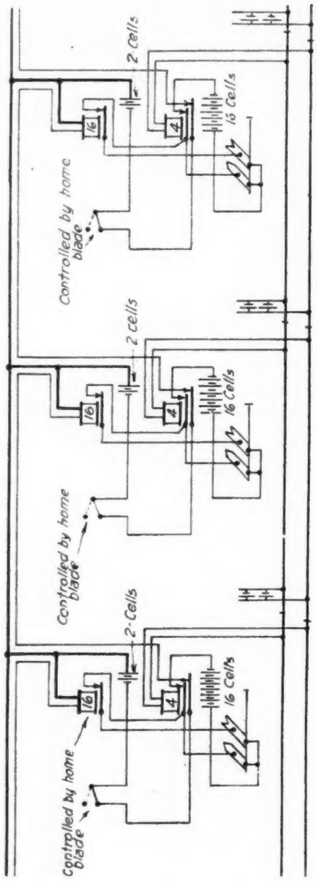


Fig. 210. Typical Circuits, Two-position Signals, Normal Clear, Boston & Albany.

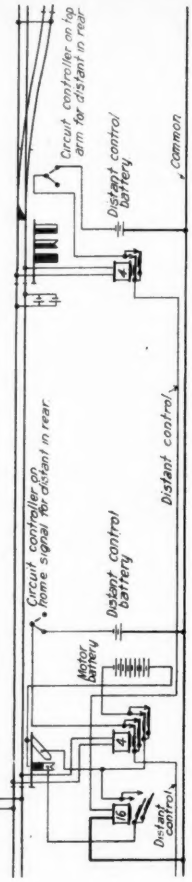


Fig. 212. Circuits for Power Operated Distant Signals, Boston & Albany.

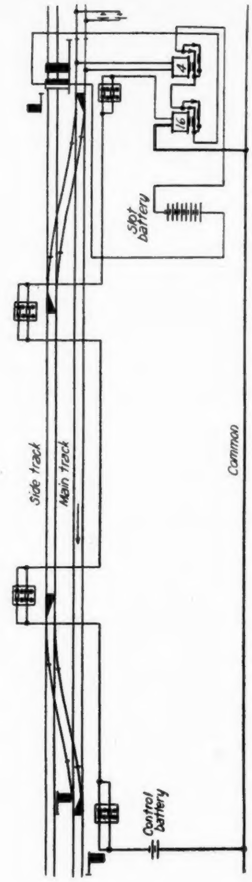


Fig. 213. Circuits for Mechanical Slotted Home Signal, Boston & Albany.

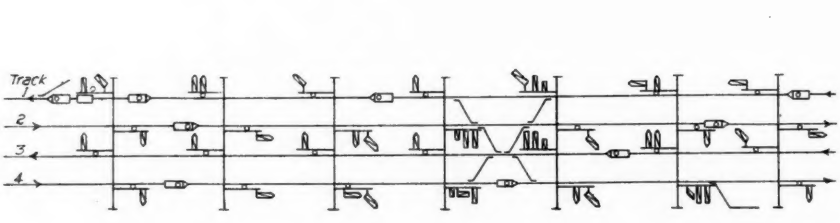


Fig. 214. Aspects of Three-position Signals Under Various Conditions of Track Occupancy, Boston & Albany.

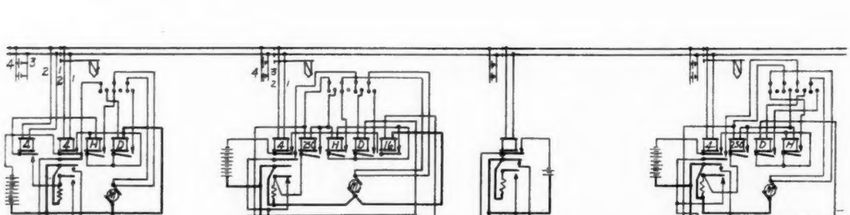


Fig. 211. Typical Circuits, for Three-Position Signals, Normal Danger, Boston & Albany.

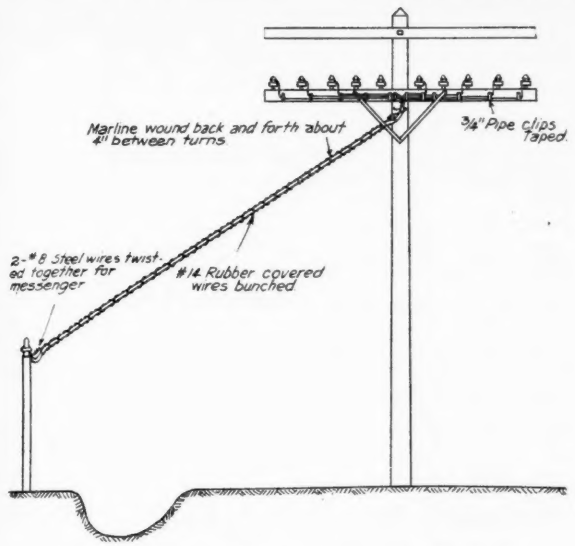


Fig. 204. Line to Cable Post, Boston & Albany.

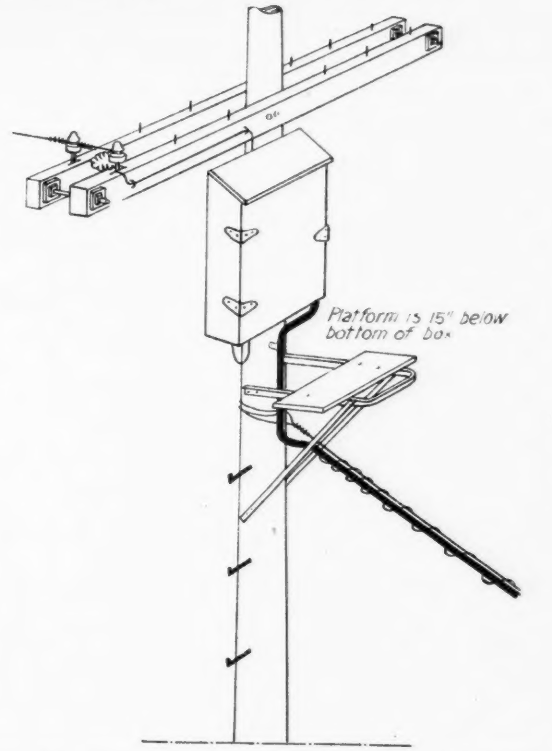


Fig. 203. Change from Line Wire to Cable, Boston & Albany.

THE CHICAGO SIGNAL CLUB.

On Monday evening, August first, a party of signalmen, railroad and supply, resident in Chicago met informally to discuss questions relating to the signaling as met with day by day in the course of their work. Before the meeting was over, a new organization, the Chicago Signal Club, was formed. Meetings are to be held at 7:00 P. M. on the second and fourth Monday of each month in Room 403 Plymouth Building and are to be open to all persons interested in railroad signaling. All meetings and discussions are to be strictly informal, there being as little organization as possible. No dues or other fees are to be charged. For convenience a chairman and secretary, Mr. W. H. Arkenburgh of the Rock Island and Mr. A. D. Cloud, respectively, were elected. It is hoped that at the next meeting, August 22, a large number of signal men will attend.

Official Nomination of the Railway Signal Association.

In accordance with the provisions of the constitution, the executive committee has presented the following list of nominees selected by the nominating committee for 1910-1911, to all members entitled to vote.

For President, C. E. Denney.

For Vice-President, B. H. Mann.

For Secretary-Treasurer, C. C. Rosenberg.

For Eastern Executive Member, F. P. Patenall.

For Western Executive Member, A. G. Shaver.

Note.—In accordance with the provision of the constitution vice-president C. C. Anthony will become the senior vice-president without further action.

The vice-president and executive members to be elected this year must be located as follows:

The vice-president from the Western Section.

One executive member from the Eastern Section.

One executive member from the Western Section.

In case additional nominees are desired such nominations must reach the secretary-treasurer before the first of August.

L. R. Byram has been appointed supervisor of signals of the Chicago Terminal division of the Rock Island at Chicago.

J. B. McCallum has been appointed acting supervisor of signals of the Iowa division of the Rock Island at Des Moines, vice L. R. Byram, transferred.

The Chicago, Rock Island & Pacific is installing three-position, upper-quadrant automatic block signals between Eldon and Cameron Junction on the Missouri division and between Linn Junction and Vinton on the Minnesota division; signals are soon to be put in service between Irving and Ft. Worth on the Southern division. All these installations are on single track.

The Chicago, Rock Island & Pacific will expend about $75,000 to $150,000 to remove its yards from within the city limits of Joliet to a point near Rock Run, Ill.

Second Annual Report of the Block Signal and Train Control Board to the Interstate Commerce Commission—Continued

The "A B C" System of Signaling on the Northern Pacific.

The "A B C" rules for train operation, prepared by Alfred Beamer, superintendent on the Northern Pacific at Spokane, were put in use on 63 miles of the Northern Pacific, single track, early in 1908, and on over 500 miles in October, 1908. The train dispatcher controls all trains without a time-table, and the block signalmen at the stations, using a separate wire distinct from the dispatcher's train wire, go through the regular operations of the telegraph block system so as to confirm the safety of the dispatcher's movements independently of his actions. Permissive movements are strictly forbidden except in rare emergencies. Mr. Beamer has taken out patents on certain features of the system (U. S. Patent 927,401; application numbers 431,940 and 515,928).

Following are the principal features of the instructions (October, 1908):

All time-card trains (both passenger and freight) previously shown on the time-tables are annulled. All the running rights that a train has at any time are conferred upon it through the medium of a block card issued by the train dispatcher.

A block is the section of main line extending from the signal at one telegraph office to the signal at the next telegraph office in advance.

Train and engine men are prohibited from accepting or running on a card purporting to authorize them to pass an open telegraph office.

No train will, except under flay protection, be allowed to leave a terminal or pass a telegraph office, no matter what may be the position of the semaphore, without both the conductor and engineer first securing a block card authorizing the train to use the block in advance.

Immediately following the departure of a train from a telegraph office the operator will report its departure to the dispatcher and to the operator at the next telegraph office in advance of the train.

Immediately upon receipt of this report the operator at the office in advance will assure himself whether the block in advance from his office is clear, and if so, he will at once ask the dispatcher in the form provided, for the book in advance for the approaching train. If his record shows the book in advance is occupied by another train, he will hold his signal against the approaching train until advised that the block in advance is clear.

Having secured the block card from the dispatcher, he will at once secure from the operator at the next office in advance a pledge of the block for the train for which the dispatcher has authorized the block card. After this has been accomplished, he will place his signal in the clear position and deliver a copy of the card to the engineer and another to the conductor as the train passes his office.

Trains approaching telegraph offices and finding signal at clear will understand from this that the block ahead is clear and will pass the telegraph offices without reducing speed, catching the block cards as they pass. If, however, from any cause the cards should not be secured, the train will be brought to an immediate stop and will not proceed until the cards are secured.

Conductors and engineers will immediately examine the block card, following its receipt by them, and make sure that it is correctly made out. They will follow implicitly all instructions given them thereon. If directed to take siding at a station, they will do so disregarding a signal to come down the main line. The rights conferred on the train by a block card can not be extended by a signal, but may be restricted by one.

When taking siding to meet an opposing train or to be passed by a following train, trains will head in at the first switch at all points where lap sidings are provided.

All exceptions, and the name of the telegraph office in advance, must be repeated to the dispatcher by the receiving operator. A card bearing no exceptions is not repeated.

When necessary to change instructions on cards that have already been put out by the dispatcher, he will invariably do so by annulling the card containing the instructions which it is desired to change. Dispatchers will when making a change in meeting or passing points, invariably use the term "instead of."

All trains will be designated by the number of the engine pulling them.

In the event of a wire failure occurring between two telegraph offices trains will simply flag across. When trouble of that kind occurs, dispatchers (in other districts) on the side of the break opposite from the dispatcher in whose territory the break occurs will be advised of the fact by the operator closest to the break, and, will move trains over the detached territory until repairs to the wire have been made.

Details of Operation, Spokane and Trout Creek.

The record shown herewith (Fig. 1) is that of an eastbound freight train on December 1, 1908, running from Spokane to Trout Creek, 133 miles. The number at the top, D F 187, is the regular designation of this manifest train each day, and the same number is retained from the Pacific coast starting point through to St. Paul, Minn. The notations in the eight lines at the heading are self-explanatory. Little more (OUT) was the engineer of engine 472, a helper running from T. C. (Tuscor) to J. (Trout Creek). Engine 248 is the regular engine of the train. The space for No. (number) at the top of the card is used in filing the records at the close of the day.

(The "train sheet," which is before the dispatcher at any given time, consist of as many of these long, narrow strips as there are trains on the road at that time. Each strip is kept between brass grooves on the table or desk, and as soon as a train has completed its trip the strip is taken out.)

The heading of the card being thus filled in, the remainder of the record is made from the bottom upward; the cards for this division being always printed so that westbound trains are to be read downward and eastbound trains upward.

"Time ordered" is the time at which the train crew was ordered to be on hand. In this case the train left promptly at the expected hour. Dispatcher Darling had charge of this movement from the starting point to Hauser, Dispatcher Wychoff from Hauser to Noxon, and Dispatcher Smith from Noxon to the end of the division.

The train started with 41 cars, weighing 1,591 tons. The first block card was No. A-188, delivered to the train at Spokane. The number of this card is entered against the next block station, Yardley, at the time the card is issued, and, of course, before the arriving time at Yardley has been entered. By this practice the dispatcher always has a clear indication of the cards which have been issued and have not been fulfilled.

Card A-196 was issued at Trent for the movement to Hauser, with an "exception" informing this train it was to take the siding at Otis (not a block station), and there meet westbound engine No. 1617.

Card A-202 was issued at Hauser for the movement at Rathdrum. The stop of eighteen minutes at Rathdrum is noted at the bottom, as having been required to take water ("RD. wtr.").

The first note at the bottom, "Otis, No. 53 (1617)," shows the train which was met at Otis, No. 53 being the designation of its character as a fast freight.

The next note indicates that there was a loss of ten minutes between Trent and Otis, because of low steam.

Returning now to the time record, we find that at [illegible] order No. A-214 was given for the movement from [illegible] Athol, with an exception to "Take siding and meet [illegible] 232 at Athol." The note at the bottom of the record, "[illegible] No. 15 and set out," means that the train met at Athol was passenger No. 15, and that there was also at that station a delay to set out one or more cars.

Card A-236, issued at Athol for the movement thence to Granite, had the exception "Take siding and let engine 161 pass at Granite."

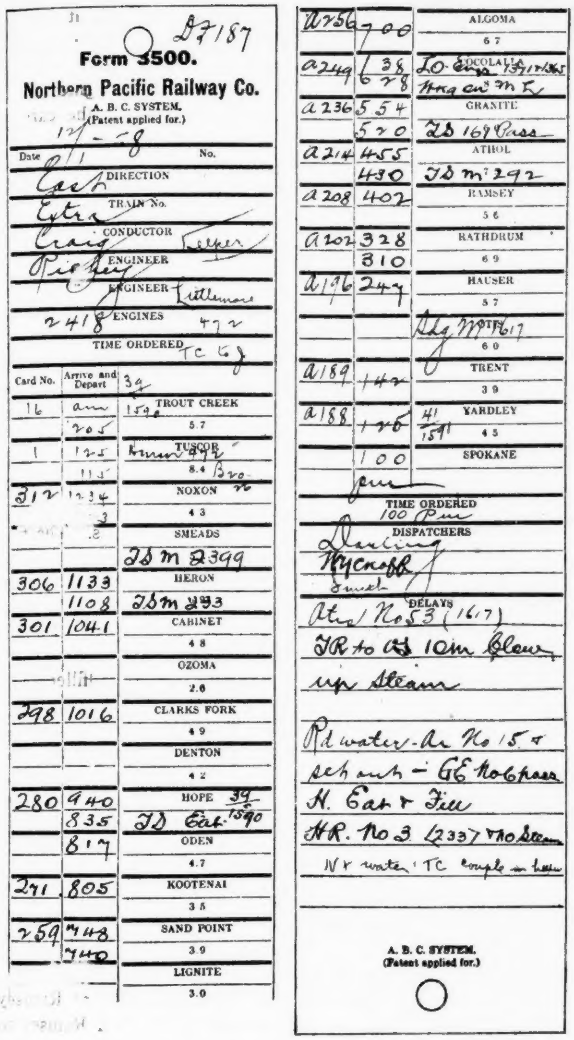
The thirty-four minutes' delay at Granite needs no explanation, as this train had to clear the block section in the rear before the passenger train (engine 161), running in the same direction, entered it, and then had to wait at Granite until the passenger had cleared the block section in advance.

Card A-249, issued at Granite for the movement from Granite to Cocolalla, contained the exception, "Look out for engines 1371 and 1365, working on main line."

Card 280, issued at Kootenai for the movement to Hope, contained the exception, "Take siding at Hope." This was not to meet any particular train, but to allow the crew a period of time, the length of which was not known, to eat their luncheons and to coal and water the engine.

This card was issued at Kootenai to run to Hope, because the office at Oden was not open at that time, 8:05 p. m.; but by the time the train reached Oden the operator had come on duty and reported the train. Oden is open at night, but not in the day time.

The notation of 39-0-1590 means that from Hope the train consisted of 39 loaded cars, and no empty cars; weight, 1,590 tons.



F. 17. Train Sheet Used with "A B C" System.

The dispatcher not being informed as to how long a time would be used at Hope, the next order would not be issued until the operator at that station, being informed by the conductor at the proper time, called for a card for the movement from Hope to Clarks Fork. It may be assumed that in this case he asked for the card at, say, 9:35. The departing time in every case indicates the actual departure of the train from the station, and not the time when the conductor gave the signal to start.

The notation at the bottom of the sheet, "H, eat and fill," means that the trainmen were to eat their luncheon at Hope, and to fill out the train with cars (some having been left at Athol).

The notation "H R No. 3 (233) and no steam," means that at Heron passenger train No. 3 was met, and that there was a delay also, because of low steam pressure. Passenger trains continue to be called by their numbers which have been in use for years, although these numbers have nothing to do with the running rights. They are of use mainly for the passenger department and for advertising.

The order issued at Noxon is No. 1, being the first number issued after midnight. This order bore the exception, "Hold main track and meet engine 472 at Tuscor." There was also another exception on this card consisting of instructions to run at a certain restricted speed over two places between Noxon and Tuscor, these notations being the substance of bulletins No. 20 and No. 26. This is the meaning of the notation on the record "B-20-26."

The last notation at the top of the card, "39-0-1590," shows the make-up of the train as it arrived at Trout Creek.

The last notation at the bottom of the card means that the delay at Noxon (Nx) was for taking water, and that the helping engine was taken on at Tuscor.

When trains meet at a "blind" siding the block cards given to the conductor and engineman confer right to the meeting point, and there the conductors secure new cards by telephone. All of the "blind" sidings are equipped with telephones.

The station operators or signalmen are held to the habit of strict attention to duty by a rule forbidding the dispatcher to offer a block card; that is, he must not authorize a train to proceed from B to C until B, having heard from A of the approach of the train, calls for the authorization. The man at B must therefore be always on hand to get his advice from A and ask for the authorization in due season so as not to delay any train.

On the other hand, the signalman is not allowed to arrange a movement and then ask the dispatcher to confirm it; for occasionally the dispatcher, with his more complete knowledge, finds it necessary to require the station signalman to hold a train, and cards are never issued long before they are needed.

Specimen block cards are shown in figure 4. The space on the cards indicated by the word "Exceptions" is used to write in any instructions which may be necessary; as, for example, in card A 214.

Block cards are given to both the conductor and the engineman, because it is a duty of the conductor to identify opposing trains at meeting points. The conductors of passenger trains are required to signal to the engineman on approaching a station where another train is to be met. On passenger trains

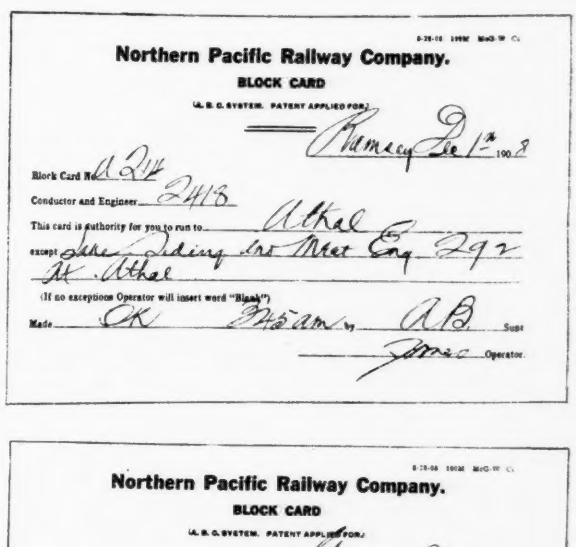


Fig. 18. Block Cards Used with "A B C" System.

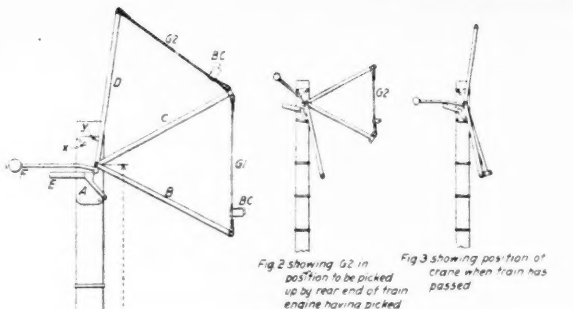


Fig. 19. Block Card Crane.

the rear brakeman catches the block cards and immediately carries them to the conductor.

Cards are called in and inspected at the superintendent's office often enough to enable the officers to keep informed as to the quality of the signalmen's work.

Provision is made for closing offices temporarily and making two block sections into one.

Procedure Prescribed for Dispatchers and Operators in Blocking Trains.

Assuming that engine 1376, an eastbound freight train, is ready to leave A. When the operator at A reports the departure of this train to the operator at B the latter immediately consults his block sheet to see the condition of the block between B and C. If found clear, the operator at B calls the dispatcher on the train wire and says, "B 1376 to C." The dispatcher consults the train slips on his desk relative to the condition of the block between B and C. If he finds it clear, he responds to the operator at B, "B C No.— to 1376 to C. O. K.," with signature. The operator at B copies this on a block card, making two carbon copies. He then calls the operator at C on the block wire and says to him "B 1376 to C." The operator at C consults his block sheet to see if the block between C and B is clear. If he finds it so, he responds to the operator at C, "I B for 1376 for C." The operator at B then places two of the cards in two hoops, placing them in the station crane, one above the other, for the engineer and the conductor of the approaching train to pick up as they pass his station, and then clears his signal governing their movement. Immediately upon the train passing B he reports the fact, giving the time to the dispatcher on the train wire and to the operator at C on the block wire.

Assuming that engine 1376 is to meet engine 1377 at D. As soon as the operator at B reports the 1376 passing there the operator at C asks the dispatcher for the block C to D. The dispatcher responds, "B C No.— to 1376 to D, except hold main line and meet engine 1377 at D." This the operator at C repeats to the dispatcher, who at the time records it on the train slip that bears the record of the movement of engine 1376, following which he gives the operator at C the O. K. The operator at C then calls the operator at D and says to him "B 1376 to D, except hold main line meet engine 1377 at D." The operator at D records this on his block sheet, and if his report shows that the block between D and C is clear, he then repeats the exception back to the operator at C, who at that time records the exception on his block sheet, following which he arranges to deliver the cards to the approaching train as above described.

In the foregoing case engine 1377, picking up the block card at E, will find that the card secured at that point gives it authority to run from E to D except take siding and meet engine 1376 at D.

All train movements involving meeting points or passing points are managed in that way, and in all cases whether involving meeting points or straight running cards the use of telegraph calls is prohibited; the name of the station must in all cases be spelled out in full.

Book-Card Crane.

The apparatus used for delivering block cards to rapidly moving trains, illustrated in the accompanying diagrams, consists principally of a piece of rope the size of old-fashioned bell cord, about 30 inches long, which is hung in a vertical position on a crane. When the rope comes in contact with the horizontal bar attached to the passing engine or car, the impact produced by the motion of the train causes the rope to quickly whirl several times around the horizontal bar, and at each turn the rope sticks between the wires of the loose coiled spring with which the horizontal bar is fitted; thus it is held and kept from falling to the ground.

The crane (Fig. 1) is 8 feet 5 inches high from the level of the rail to the spindle supporting the arms, and it is set 7 feet from the track. In Figure 1 the arms, with the ropes, are in position to deliver the cards (B C), one fastened to each rope, to an approaching train. Rope G-1 is in position to deliver to the engineman. When this rope is caught by the engine, arm C falls by gravity to the position of B, and rope G-2 is then in position to be taken by the catcher on the caboose or rear car of the train. Arm B, in falling, strikes and depresses detent E, thus releasing arm D, which falls with arm C. The counterweight F, striking against stop x, keeps arm D from falling too far, and stop y limits the motion of F and D in the other direction.

Fig. 2 shows the position of the arms after the engine has passed and while rope B-2 is in working position; and Fig. 3 shows the position of the arms after the train has passed. Figure 4 shows the locomotive fixture, and Fig. 5 the fixture for the rear of the train.

The behavior of this apparatus is reported as entirely satisfactory; cards have been picked up at all speeds up to 65 miles an hour. The catcher for the rear of the train is made to fit into the bracket used for supporting the tail lamps, and is detachable. Each train crew carries two of these rear-end catchers. They are made of 3-8 inch iron pipe.

No light is provided for the station crane, as the crane in each case is fixed directly in front of the telegraph office, so that the station signal light locates it.

TITANIUM

Report of the Block Signal and Train Control Board on the Use of Titanium Alloy in Rails for Railroad Track.

The question of the value of certain improvements in the manufacture of rails by the use of titanium alloy having been brought before the board, an investigation of the subject was made, including inquiries of metallurgical experts and others familiar with the manufacture and use of steel rails, and a report was made to the parties who brought the matter before the board, in substance as follows:

It appears that titanium alloy is made in America under the so-called "Rossi process," it being claimed that the use of the alloy results in increased strength of the rail and freedom from brittleness, and that by its use there is entire freedom from slag and segregations, the ingots being free from blowholes. While neither an appliance nor a system, it is contended that

titanium alloy, by improving the process of manufacturing railroad rails, contributes to the safety of railway travel, and is therefore a proper subject for investigation by this board. The board has so accepted it. The advantages claimed for titanium alloy are summarized as follows:

The alloy releases the occluded gases, remarkably increases the quantity of slag removed, increases the elastic limit of the steel, makes the rail less brittle, more ductile, more durable, and vastly more safe.

Through this greater ductility mentioned the use of a higher carbon is entirely practicable, thus still more improving the durability or wearing quality of the rail, yet with absolute freedom from brittleness.

Another marked advantage claimed for this alloy is that it is distinctly a commercial proposition. In other words, the cost of the alloy in the steel is but $2.80 per gross ton of steel melted, or allowing for the waste in present percentage of ingot discarded, etc., the additional cost of rail would be under $5 per gross ton, or less than one-fourth of a cent per pound, as per figures given by manufacturers of Bessemer rails.

It appears that somewhat extended experiments were made with titanium in connection with crucible steel as long ago as 1890, but with unsatisfactory results. By using an electric furnace a 5 per cent alloy of titanium was made with which a steel containing as high as 1 per cent of titanium was obtainable; but on remelting the steel all of the titanium slagged out, there being some loss even by the ordinary reheating of the ingots for forging or rolling. A chemical examination of so-called "titanium" steels on the market at the time failed to reveal even a trace of titanium in them, and physical tests failed to show any improvements over regular steel. As a result of these early tests it was concluded that titanium had no function in high carbon steel; but owing to its strong affinity for nitrogen, titanium might prove useful in Bessemer steels, in which the nitrogen content is much higher than in tool steels.

More recent investigation has apparently demonstrated the truth of this prediction for low carbon steels.

Ferrotitanium, besides being an energetic deoxidizer, acts to reduce the nitrogen content in steel when used as a subsidiary agent in connection with the manganese and silicon of the recarburizer. The crushed ferrotitanium is added to the ladle as the steel is being poured from the converter in the same way as ferromanganese and other recarburizing agents. To accomplish the best results, however, time must be allowed for the deoxidizing process. By its use it has been found possible to increase the carbon in steel rails from 0.45 to 0.50, with still greater probable increases, particularly in open-hearth steels.

Stated in more detail, it appears that rail steel as made in recent years is more or less overoxidized and contains hydrogen and nitrogen either mechanically or chemically bound. The ordinary processes of recarburizing reduce this overoxidization only partially. Were more time taken between the addition of the recarburizing materials and pouring a more complete deoxidation would take place. In consequence of the haste used the gases present in molten metal are retained in the ingot after being cooled. Carbonic oxide is formed during the cooling, which sets free hydrogen and nitrogen. The rapid setting of steel prevents, under ordinary conditions, the formation of blowholes, so that the liberated hydrogen and nitrogen gases are distributed throughout the mass of steel as "intercrystalline" gases, rendering the fracture of the ingot somewhat flaky and inferior as to density. Notwithstanding the subsequent rolling condenses the metal, the gases are still contained therein, with the result that the rails are rendered more brittle, particularly in cold weather.

Although the percentage of these gases is small their effect is virulent; and the fact that steel rails are rarely analyzed for hydrogen and nitrogen contents make their presence all the more dangerous.

Hydrogen, it appears, is not easily eliminated if it can be eliminated at all. Oxygen can be eliminated in a number of ways, one of them being by the use of titanium, while nitrogen can be eliminated with positive results only by the use of titanium. The affinity of titanium for oxygen is so rapid as to remove the last traces of oxygen in a very short time. Manganese also removes oxygen, but requires a longer time. The fact that titanium combines with both the oxygen and the nitrogen contained in the metal is important as concerns the oxygen in the saving of time, and as concerns the nitrogen as being positive.

The effect of nitrogen on iron (ferrite) may be described more particularly as follows: A solid solution results which is extremely brittle, being easily torn apart in crystallization. The metal is spongy well down in the ingot towards the bottom along the main axis, resembling a pipe, and it may perhaps justly be called a "pipe." When titanium has been added and the nitrogen eliminated the metal is stronger and can not be torn apart in crystallizing. The metal, therefore, does not exhibit the spongy line well down in the ingot near the bottom. Such ingots have, however, their natural pipes sharply defined at their upper ends.

The effect of the titanium, therefore, is to produce a more dense metal, one free from slag inclosures, making it possible to use a higher percentage of carbon, thereby securing a higher elastic limit, greater hardness, and increased wearing qualities, without a rapid decrease in ductility.

As regards the physical results obtained from the use of titanium steel rails, it is to be said that while there have been several installations none of them has yet been long enough in service to afford a complete demonstration of the results claimed for the metal.

It appears that in certain tracks in the yard of the Grand Central Station, New York, the wear in six months on a 10 deg. curve (at Fifty-sixth street) was found to be much less than on the ordinary 1907 rails which preceded them; also that similar rails laid on the 12 deg. curve at the entrance of Lexington Avenue Station are resisting flange wear equally well. Titanium (80-pound) rails in use on the West Shore are reported as doing well, but the results with the 100-pound rails on the Boston & Albany will not be known until after a cold winter. The Pennsylvania has also purchased a quantity of the rails for test, and the Baltimore & Ohio a few of them, but the results are not yet known.

Titanium alloy appears to be a somewhat expensive agent to use in steel rail making, notwithstanding the price for a 10-per-cent alloy, since the electric furnace has been improved, has dropped from 25 cents to 12½ cents a pound. The cost of the rails naturally depends on the amount of the alloy added. Late purchases have cost about $2 a ton more than ordinary rails. Like other alloys, titanium must be adapted for the conditions to be served. A higher percentage could be used for tracks traversed only at low speeds than for those which must bear high speeds; and its use varies with the different ores; also with the size of ingots, heating, blowing, and rolling processes. For these reasons titanium rails must be made under specifications carefully drawn by an expert in the use of the alloy. Moreover, it appears probable that until the processes of manufacture have been standardized it will not be practicable for different mills to engage in the manufacture of titanium rails in commercial competition.

It will be observed that much stress has been laid on the time element required, after the molten metal has been poured into the ladle and has received its charge of deoxidizing and recarbonizing materials, for the reaction to take place and for the gases to escape. It is believed that one of the causes, if not the chief cause, of the poor quality of rails made in the ten-year period from 1898 to 1908 lies in the reduction of the time element to such an extent that the process was left incomplete; and it is queried whether on final solution this cause may not be found to be due to the craze for increased produc-

tion at decreased cost—not to the consumer in this case, but to the manufacturer. Prior to 1898, that is, in the period from 1890 to 1898, steel rails were made of a very satisfactory quality, and since 1908 rails have greatly improved. This is well illustrated from the present requirement of from twenty to twenty-two minutes from the beginning of the blow in the Bessemer process to the teeming of the ingots, as against nine minutes used in the years just preceding 1908.

After carefully considering all the information received the board has reached the following conclusions: That while the use of titanium alloy affords promise of a better rail, particularly as relates to its durability, it is not yet clear that it has added to the safety of rails when compared with the rail products of 1890-1898; that the trouble with rails since that date is apparently due to manufacturing faults; and that by a return to the older processes of manufacture rails may still be produced of dependable soundness. Further, that the use of titanium alloy, being apparently of first advantage to the manufacturer, and in that respect a commercial advantage, it is not one in which the public is primarily interested; and that consequently this board can do no more at the present time than to encourage the further use of titanium rails under various conditions of roadway and of railway traffic, with a view to establishing definitely all facts pertaining to their use.

THE ROWELL-POTTER SAFETY STOP.

The Block Signal and Train Control Board has carefully considered the plans and descriptive matter presented by the Rowell-Potter Safety Stop Company, covering an automatic block signal and train control system for both single and double track, and has conducted tests of an installation of this system upon the tracks of the Chicago, Burlington & Quincy Railroad near Aurora, Ill.

The apparatus and system submitted are covered by the following patents, and it is understood that other patents are pending covering recent developments: 542313, dated July 9, 1895; 556773, dated March 24, 1896; 584962, dated June 22, 1897; 584963, dated June 22, 1897; 599456, dated Feb. 22, 1898; 607762, dated July 19, 1898; 658509, dated Sept. 25, 1900; 671032, dated April 2, 1901; 724947, dated April 7, 1903; 770656, dated Sept. 20, 1904; 770657, dated Sept. 20, 1904; 774498, dated Nov. 8, 1904; 776146, dated Nov. 29, 1904.

The distinctive features of the system are as follows:

(1) Power for the operation of the signals and the mechanical trip train stops is obtained from the energy of moving trains and stored in coil springs.

(2) The mechanical-trip train stops are arranged in duplicate and so interconnected that when one trip is in operative position the other is in inoperative position.

In the installation examined, the spring power-storing mechanism was actuated by the deflection of the rails of the track under the wheels of passing trains. This method was abandoned as unsatisfactory, and for the major portion of the time that the installation was in operation the power-storing machine was operated by a treadle bar so mounted along the outside of the rail as to be depressed by the treads of passing wheels, the motion of the treadle bar being communicated through levers to the spring drums.

The system will be considered herein under the following headings: (1) History; (2) Analysis of apparatus; (3) Analysis of tests; (4) Discussion; and (5) Conclusions.

HISTORY.

The first installation of the Rowell-Potter system of automatic control was made in 1891 on the Boston, Revere Beach & Lynn Railroad. In this installation ground trips were operated mechanically by connections from interlocking plants to engage air-brake valves mounted on the locomotive. This installation was in service about two years.

The second installation was made in 1893 on the Intramural Railway at the World's Fair, Chicago, there being 21 automatic block signals, all being equipped with automatic trip devices. This installation remained in service during the fair period.

The third installation was made during 1893 and 1894, consisting of 37 automatic signals and trip devices, installed on the Chicago & South Side Rapid Transit Railroad, remaining in service several years.

The fourth installation was made during 1894 and 1895 on the Metropolitan West Side Elevated Railroad of Chicago, consisting of 36 automatic signals and track trips, remaining in service several years.

The fifth installation was an automatic interlocking plant at Hawley, Ill., at the crossing of the St. Louis, Peoria & Northern with the Peoria, Decatur & Evansville. Derails were used on the Peoria, Decatur & Evansville track, while the engines of the St. Louis, Peoria & Northern were equipped with automatic stop devices ,the track each side of the crossing being equipped with trip devices. The length of time which this plant remained in service is not given, but the correspondence indicates that it was in service at least one winter.

The sixth installation was on the Chicago, Milwaukee & St. Paul Railway between Pacific Junction and Edgebrook, consisting of four automatic block signals with track trips. The number of engines equipped with automatic stop devices is not given in this case, nor in any of the other installations referred to. This installation remained in service from May 19, 1902, until Dec. 8, 1902.

The seventh installation was on the Chicago, Burlington & Quincy Railroad during 1908 for test purposes. The installation was made up of two sections, the first being put into service Oct. 16, 1908, on the single track between Sugar Grove and Big Rock, Ill., a distance of about five miles, remaining in service until April 30, 1909. The installation consisted of four signal posts, carrying eight home and two distant arms, each post carrying a home-signal arm governing movements in each direction. The distant arms were located on the two middle posts and were so controlled as to indicate the position of the passing track switches at Sugar Grove and Big Rock, as well as the position of the home signals in advance.

The second section was on the westbound main track between Eola and Aurora, Ill., consisting of two home signals protecting the track between milepost No. 34 and S. Y. yard office. These signals were placed in service Oct. 22, 1908, remaining in service until April 30, 1909.

During the winter months an inspector of the Block Signal and Train Control Board kept careful record of the operation of the signals and stop apparatus.

ANALYSIS OF APPARATUS.

Power-storing machine.—As stated at the beginning of the report, the distinctive feature of this system is the operation of the signals and track trips by electrically controlled mechanical power, which is stored by winding coiled springs in a drum. An iron bar is placed outside of and close to the head of the rail, the top of the bar standing normally slightly above the top of the rail, and is connected to the springs by levers and ratchets, so that when the bar is depressed by the wheels of a passing train the springs are wound up. The arrangement of the bar, levers and storing machine is such that the passing of an engine with two cars will store sufficient power to operate the apparatus for the next train.

The capacity of the springs is such that upon being completely wound up sufficient power is stored to operate the apparatus from thirteen to twenty-three times, as shown by the reports, apparently depending upon the condition of the apparatus. A cut-out is provided in connection with the winding apparatus to throw it out of operation when the springs are fully wound. It is thrown in again when a certain predetermined amount of power has been used, both operations being automatic.

A lock is provided to automatically lock the apparatus in

the normal position (signals at stop) should the power become exhausted.

The power-storing machine is controlled by electro-magnets, which are in turn controlled by the track circuits, either directly or through line relays, as the case may be.

Signals.—The signals used are of the semaphore type, and are operated directly from the power-storing machine by connections of cranks and rods. Power is used to move the signals from the stop to the clear position, and also from the clear position to the stop, a counterweight being provided which would move the signal to the stop position should any break occur in the connections between the signal and the power-storing machine. The signal arms are locked in the stop position to prevent clearing by hand.

As the signal arms for opposite directions on the single track are mounted on the same post and operated from one power machine, a selector in the machine is necessary. This is so arranged that the proper arm is cleared, depending upon the direction in which the train is moving, and at the same time changes the position of the track trips when necessary. The selector is controlled by an electro-magnet, which is in turn controlled by the track circuits.

The distant signals are operated by a separate spring motor or power machine, which is housed in the base of the signal post, being wound from the main power machine.

Circuits.—The signals are controlled by the usual arrangement of track circuits, all switches in the track being equipped with switch boxes.

Track instruments.—The track instrument or trip for the engine valve consists of two iron bars lying parallel to the track rail near the ends of the track ties, being lapped and joined by a pivot at the center and fulcrumed at the other ends, being so connected by a rocker shaft and cranks to the power machine as to be raised into or lowered out of position to open an air-brake valve mounted on the locomotive tender truck.

The distinctive feature of this track instrument is that the trips are in duplicate, the two parts being connected by rigid mechanical connections and so arranged that one trip is always in position to open the train valve.

The trips are located about 180 feet apart, and the home signal is located at the central point between. The distant signals are operated by separate power machines.

A train upon approaching a clear signal finds the first trip lowered out of engaging position, and upon passing over it sets the signal to the stop position, which raises the rear trip and lowers the one in advance of the signal. Should the signal fail to go to the stop position the second trip would not be lowered and not being lowered it would open the train valve. This feature thus provides for stopping the train in the event of the home signal sticking in the clear position.

Engine apparatus.—The engine machine or air-brake train-line valve is fastened to the axle box on the front end of the rear tender truck in position to have its plunger engaged by the upper inclined surface of the track trip when it is in the raised or operative position. Guards or scrapers are placed on the forward end of the forward tender truck and rear end of rear truck to prevent any obstruction beside the trip striking the valve plunger.

Whenever a trip is encountered in the raised or tripping position, it is first engaged and depressed by the scraper or plow and restored by springs to its raised position in time to engage the engine valve.

The trip has an incline of 1 in. in 30 ins. and the valve plunger which moves vertically is provided with a lock which is released by the raising of a second plunger placed directly back of the valve plunger. The two plungers are so arranged that when engaging the track trip the unlock plunger will be raised first unlocking the valve plunger, allowing it to be raised. The valve upon being opened is locked in this position until released by a plunger. This release can be effected only by a man on the ground.

Insulated joints.—The insulated track joints used in this installation appear to have given very good service. The inside angle bar is the same as used on a standard non-insulated joint, except that it is smaller to allow the fiber insulating material to be placed between it and the rail. The outside angle bar is of special design, having a wider bearing on the tie, being about 1 in. thick at the top, which is level with the top of the rail. Fiber insulation is placed between it and the rail and also between the bolts and the angle bars.

General.—The test installations of this system on the Chicago, Burlington & Quincy Railroad on the double track east of Aurora and the single track west of Aurora, Ill., were under the observation of the board or its inspector during the period from Dec. 4, 1908, to April 30, 1909. During that period there were recorded 48,352 signal movements with 89 signal failures, and 31,013 automatic stop movements with 11 failures, showing one signal failure in 543 signal movements and one automatic stop failure in 2,820 movements. In two of the 89 signal failures the signals stuck at clear, though it is to be remembered that in this event the advance trip remains set to stop the train. The 11 automatic stop failures recorded were cases in which during a stop test the automatic trip failed to stop the train. Two hundred and twenty-two of these stop tests were made, 189 of them by the trains passing a signal which was in the stop position, either from intent or because of a train block. Ten of the stop tests were made with the signal remaining in the clear position, so that the train was stopped by the advance trip rather than by the rear trip. Twelve of the stop tests occurred as a result of signals failing in the stop position.

A bald statement of the number of signal and stop movements per failure indicates a rather unsatisfactory showing, but an analysis of the results places the mechanisms in a more favorable light.

Engine equipment performance.—An examination of the reports shows that out of 222 stop tests there were 11 cases where the brakes would not apply properly when the engine passed over track trips which were in the raised position. All of these occurred in the first 98 tests. Three of these cases are clearly chargeable to insufficient width of the engine-valve slide, and it appears that no failures of this kind occurred after a 6-in. slide was substituted for the 4-in. slide. Five cases are reported where the failure was caused by damage to the engine valve due to its striking an obstruction apparently while engaged in switching in a gravel pit. One failure is chargeable to the breaking of the lug on the lock slide, which prevented it from unlocking the main slide, thus preventing the valve from opening. This damage appears to have been caused by a pile of frozen coal obstructing the clearance on a siding. Two failures are of doubtful origin. They should probably be charged either to the damaged engine valve or to the insufficient width of the engine-valve slide. It is proper to note that the two engines equipped for this test were used on local freight trains and were required to do switching at a gravel pit where clearances were not maintained.

The defects of the engine valve appear to be the most serious of those occurring and a number of them appear to be due to what must be considered faulty design in that the tendency of the air pressure and of the spring is to hold the valve closed rather than to open it.

Signal performance.—Inspection reports show 89 signal failures, 87 of them being failures in the stop position, with two failures in the clear position. On Dec. 8 signal No. 2 on the double track failed in the clear position, due to the locking dog on the power-storing machine being too long. After shortening this dog no further failures occurred from this cause. The report of Jan. 30 shows all signals on the single track out of service on account of snow packing in the power machines. It also shows home signal No. 4 westward and

distant signal No. 3 westward failing in the clear position. These failures are not included in the 89 mentioned above. In all cases of "clear" failure the second track trip was in the engaging position.

The possibility of signals in this system failing in the "clear" position is much greater than with the standard types of electrically operated signals on account of the semaphore arm being directly connected to the power-storing machines and because it is necessary for the machine to complete its stroke before the signal can return to the stop position. While it is true that the power stored in the springs is used to move the signal to stop, the chances of failing in the clear position when the power is exhausted are considerable.

In connection with the signal failures it is well to note that a considerable number of them were due to track-circuit trouble which occurred on account of the roadbed not being properly prepared for the reception of track circuit.

Track instrument performance.—The reports show eight failures of track instruments or trips, all occurring prior to Feb. 1. Most of this trouble was due to the fact that the supporting coil springs did not permit the trips a sufficient depression under passing trains. A number of the trips were struck by parts of vehicles not conforming to standard clearance lines. By a change of springs and some change in the controlling circuits causing a quicker reversal of the duplex trips, the trouble with them was overcome.

Power-storing machine performance.—It is proper to note that the first method employed for storing power in the machines for operating the trips and signals was by rail deflection. This method worked with reasonable satisfaction until the ground froze, when it was found quite inadequate, and treadle bars applied parallel to and outside of the head of the rail and arranged to be depressed by the tread of the wheel, were substituted. The operation of these treadle bars is reported by the inspector as being successful, and it is noted that the power machines were wound full and the power-storing gear cut out of engagement most of the time. The inspector reports the operation of the power machines as being very satisfactory. A few shaft keys and bolts worked loose and once it was found necessary to open the drums of one machine to oil the springs. The electric locks for releasing the power machines gave some trouble, due chiefly to adjusting screws working loose or to moisture freezing on the parts. In the machines themselves, there was little breakage of parts. On the single track the mechanical selector was the cause of several failures, principally from a lack of knowledge of the proper adjustment of the machine on the part of the maintenance force, and also to inaccessibility of parts, and a somewhat crude design, which it is understood is intended to be remedied on future installations.

The housing of the power-storing machines was found to be unsatisfactory in times of severe snow. Failures due to improper details of design in the signal heads and lamps, in the stop castings, line relays, track relays and circuits were present to some extent, but were due primarily to the fact that apparatus of new design was chiefly used rather than standard apparatus which had been tested thoroughly in previous service.

Insulated joints.—The insulated joints used were of an original design and stood the service to which they were subjected very well.

DISCUSSION.

Mechanical-trip train stops of the ground type have been used for some years and with a considerable measure of success on electric railways situated on elevated structures or in subways, in Boston and New York, and more recently in Philadelphia, but so far as the board is aware, no devices embodying the principal features of the Rowell-Potter system have had extended use under the conditions of steam surface railroad operation. Hence there is very little precedent or data upon which to base comparisons, and it is, therefore, necessary to consider the system presented from the standpoint of the characteristics which it is believed any automatic train-control system should possess.

The art of automatic train control is, as compared with most other arts, new, and while the board has never adopted any definite statement of requisites to which an automatic train-control system should conform, it believes that there are certain desirable features which every such system should possess in order to meet fully the requirements of safety, of reliability, of flexibility, and of economy of operation which the best railroad practice would impose. Devices might operate satisfactorily in one situation under known and fixed conditions which would be quite unsuitable for other situations. Doubtless a considerable number of collisions that have occurred upon railroads in this country could have been prevented by the use of an extremely simple form of mechanical trip, operated in connection with manual block or even with train-order signals. The board is of the opinion, however, that while certain devices may be far superior to others of the same class, certain classes of automatic train-control systems, when properly developed, will be found far superior to other types or classes in the completeness of the protection which they afford.

To obtain the greatest possible benefit from its use, and in order to be wholly desirable, the board believes that any system of automatic train control should possess the following characteristics:

(1) The apparatus should be so constructed that the removal or failure of any essential part would cause the display of the stop signal and the application of the train brakes.

If electric circuits are employed they should be so designed that the occurrence of a break, cross or ground, or a failure of the source of energy in any of the circuits would cause the display of the stop signal and the application of the train brakes.

(2) The apparatus should be so designed that it may be used upon the open roadway, on bridges, on elevated structures, in tunnels or subways, and where either steam or electricity is used as the propelling power.

(3) The apparatus should be so constructed as to conform to recognized standards of clearance for rolling equipment and structures, so that those portions of the apparatus placed upon the roadway will not be subjected to damage by rolling stock or engines, nor those portions placed upon the vehicles be damaged by any structures permitted to exist upon the roadway; and at the same time, all vehicle parts and roadway parts which may have to come into operative relation should be so designed that proper operative relation will be assured under all conditions of speed, weather, wear of track or vehicles, oscillation and shock.

(4) The system should operate under all weather conditions which permit the operation of trains.

(5) The system should be capable of control by the ordinary means used for indicating the condition of the block about to be entered, such as electric track circuit.

(6) The engine apparatus should be so constructed as to prevent release of brakes after an application has been made until the train has been brought to a stop, or the obstruction or other conditions which caused the application have been removed.

(7) The system should be so designed that should operating conditions require it, speed control may be used; that is, provision should be made for a train to pass an automatic stop in tripping position without the application of the brakes, provided the speed is less than a predetermined number of miles per hour.

(8) The system should be so designed that when no cause for stopping a train exists, a definite and positive clear or proceed indication will be given at every point where a stop indi-

cation would be given or the brakes applied when adverse or dangerous conditions existed.

(9) The system should provide, at least for use under congested traffic, for a continuous display of indications rather than for their intermittent display at certain definite points, as of course is necessary with fixed signals.

It is possible that other conditions may develop as the result of the use of automatic train-control systems, which it will be found necessary to meet, and it is possible that experience will develop the necessity for a modification of some of the characteristics described.

An examination of the plans and descriptions of the system and a study of the records of tests made on the experimental installation on the Chicago, Burlington & Quincy disclose the following facts in regard to the Rowell-Potter system when examined in the light of the desirable characteristics above referred to:

Characteristic No. 1.—It is doubtful if any form of mechanical trip device can completely possess this desirable characteristic. It is obvious that if the ground trip is broken off or removed it cannot stop the train, and to this extent mechanical systems would fall within the category of what would be called in an electrical system "open-circuit" devices. Nevertheless, it is believed that by proper design and construction, and especially by the duplicate principle employed in the Rowell-Potter system, mechanical trips can be made to operate with a very considerable degree of reliability, even under adverse weather conditions.

This system appears to possess the desirable features of characteristic No. 1 to a greater degree than any other mechanical trip examined by the board to date. The failures due to the valve closing after being opened are, it is believed, the most serious; and it must be said that the engine air valve used does not possess characteristic No. 1 to a proper degree. It is the opinion of the board that no valve should be used for this purpose except one in which the train-line pressure will tend to open it and hold it open. The electrical features of the test installation do not possess characteristic No. 1, in that the line circuits are improperly designed. This, of course, is not inherent in the system, as the arrangement of batteries and apparatus in the circuits could probably be changed to a satisfactory one without difficulty.

Characteristic No. 2.—The apparatus conforms to characteristic No. 2, though some changes would probably be necessary in the arrangement of the connections between the track and the power-storing machine if the system were to be used on elevated lines or in subways.

Characteristic No. 3.—Apparently the question of clearance has been well taken care of in the test installation. Modifications in celarance would undoubtedly have to be made to suit the requirements of special situations.

Characteristic No. 4.—Inspection reports show but one failure due to sleet or ice during the tests. The connection between the trips and the power machines were not housed in. It is probable that with proper housing of these connections and of the power-storing machines themselves failures from severe weather conditions would not occur.

Characteristic No. 5.—The system as installed takes full advantage of the use of the electric track circuit.

Characteristic No. 6.—With the apparatus arranged as shown it might be possible for a trainman to drop to the ground and release the engine air valve before the train had come to a full stop, yet the speed of the train would be so reduced that for all practical purposes the desired result would be obtained notwithstanding.

Characteristic No. 7.—The system as presented makes no provision for speed control, though it appears to be capable of having any one of several forms of speed-control devices applied to it to permit the train to pass a stop in tripping position without a brake application, provided the speed is reduced below a predetermined number of miles per hour.

Characteristic No. 8.—The system provides no indication upon the engine to denote that a train is passing a point at which a brake application might be made were the conditions unfavorable. While, as presented, it is intended to be used only in connection with a system of fixed signals, it is the opinion of the board that the giving of a definite and positive clear or proceed indication at every signaling point, when no cause exists for stopping the train, is a very desirable characteristic. In a cab-signal system unaccompanied by fixed signals, the possession of this characteristic would be an absolute requisite.

Characteristic No. 9.—One of the most desirable objects which may be accomplished by the production of effects on the engine by signaling or controlling devices along the track is the production of a continuous effect rather than the mere display of an intermittent indication such as is inherent with any system of fixed signals. The length of time any fixed signal is within view of the engineman of a moving train is comparatively short. He remains in his cab continuously while the engine is running, and any system which aims to produce effects upon the engine should, in order to be of maximum benefit, produce these effects continuously, or so long as the conditions which cause them exist. There is undoubtedly a large field for devices which exercise control or display indications upon the engine intermittently, but the value of such devices would undoubtedly be enhanced if the control could be exercised or the indications displayed continuously.

The Rowell-Potter system embodies four distinct features, and while the system, as a whole, requires for its proper operation the coordination of these four features, each of them must be considered on its merits, as well as in its relation to the others. The four features of the system are:

1. A train-actuated machine for the storage of power for the operation of signals and train stops.
2. An automatic block-signal system.
3. Mechanical-trip train stops.
4. An engine air-brake valve to be operated by a mechanical-trip train stop.

In respect to the system, the board has arrived at the following conclusions:

CONCLUSIONS.

Train-operated power-storing machines.—The board assumes that a sufficient number of these installations has not as yet been made to determine what their cost would be if the apparatus were manufactured in considerable quantity. The board is concerned with the element of cost only in so far as it has to do with the ability of railroads to install appliances or systems for the promotion of safety in their operation. It is obvious that the first cost of installation of this system would be very considerable, but it is not known to what extent this cost would be offset by the diminished cost of operation. The board has no data as to the ultimate relative economy of this system as compared with any others.

Automatic block system.—As an automatic block-signal system, the Rowell-Potter devices, aside from probable decreased cost of operation, can not be said to possess exceptional merit. It is the opinion of the board that in any system of automatic block signaling without the use of automatic stops, gravity is the only force permissible for restoring the signal to the stop position. This system requires the use of power from the coil springs to restore the signal to the stop position. While it is recognized that the air brake will be applied by the train stop in the event of the signal sticking at clear, it is held that the system would be much more commendable if the power machine were used only for clearing the signal and if the signal were arranged to go to the stop position by gravity whenever the electrical controlling device becomes deenergized.

Mechanical-trip train stops.—The duplicate arrangements of two train stops so connected that one is always in the engaging position while the other is withdrawn, is a very commendable feature for use with an automatic block system or wherever

operating conditions permit its use. It is believed that the design of the trips is good in that they move vertically into tripping position and present an inclined surface to the engine valve, and in that their fin-like construction affords ample stiffness to resist impact and a minimum of resistance to movement through snow or sand. The introduction of springs in the connections used to move the stops into tripping position can only be considered as affording a desirable degree of safety when the springs are so designed, as those under consideration appear to be, that a breakage of the springs will not affect the movement of the trips sufficiently to prevent the engine valve being opened.

Engine air-brake valve.—The board's opinion is that the engine valve of the Rowell-Potter installation worked well in spite of, rather than because of, its design. It is theoretically unsound in that spring pressure and the train-line air pressure tend to hold it closed rather than to open it. There appears to be no reason why a valve of the same general design but constructed on correct principles should not work better.

The System as a whole.—As regards the system taken as a whole, the board concludes that if the faults herein mentioned were remedied, and it sees no reason why they should not be substantially overcome, and if the apparatus were well inspected and maintained, the system would be safe and reliable and its use would tend materially to promote safety of operation on a railroad using it. As to its economy, there are not sufficient data from which to form a conclusion of any real value.

Description of the Rowell-Potter Safety Stop Company Devices as Installed on Chicago, Burlington & Quincy Railroad, 1908-1909, Under Authority of Block Signal and Train Control Board of the Interstate Commerce Commission.

GOVERNMENT ESTIMATES OF FORESTS.

During the present field season it is anticipated that the estimates covering the Apache, Gila, and Pecos, in New Mexico, and the Mount Graham division of the Crook, in Arizona, can be completed, and that for the Manzano, in New Mexico, which was estimated in 1908, thoroughly revised. During the winter of 1910 and 1911 undoubtedly the Choctawhatchee and Ocala, in Florida, and the Arkansas and Ozark, in Arkansas, can be finished. Thus, it is likely that by 1913 all saw timber in district 3, which comprises the forests of the South and Southwest, will be cruised and mapped so that purchasers can negotiate sales promptly and the government will know just what timber should be sold first and how much it can safely dispose of.

Roadmaster's and Maintenance of Way Association.

The twenty-eighth annual convention of the Roadmasters' & Maintenance of Way Association will be held at the Great Northern hotel, Chicago, September 13 to 16, 1910. The convention will be called to order at 10:30 a. m., Tuesday, September 13. The subjects selected for discussion at these meetings are as follows:

1. Proper Care of Track Material and Tools.
2. Cattle Guards.
3. New and Improved Appliances, Including Ties.
4. Standard Switch Target.
5. Rail Fastenings, Including Insulated Joints.
6. Tie Plates and Rail Anchors.

Paper on Treated Timber, by J. L. Single.

Paper on subject to be selected by himself, by W. M. Camp.

Topical questions for discussion:—(a) Dressing of gravel ballasted track. (b) Paving of ditches. (c) Length and size of ties. (d) How to drain the midway of double track, whether by surface ditches or by tile drains. (e) Should the gage on curves be readjusted to the side of the rail head, and by moving which rail. (f) Quality of track labor.

R. E. Gaut, engineer bridges and buildings of the Illinois Central, has resigned to accept a position with the Leonard Construction Co., Chicago. F. L. Thompson, assistant engineer of bridges, succeeds Mr. Gaut.

R. P. Black, division engineer of the Kanawha & Michigan at Charleston, W. Va., has been appointed engineer maintenance of way, with office at Charleston, W. Va., and the office of division engineer has been abolished.

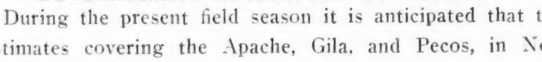
Fred L. Thompson, engineer of bridges and buildings of the Illinois Central, with office at Chicago, was born in February, 1872, at Grandview, Ill. He graduated with the B. S. degree in civil engineering from the University of Illinois in 1896, and began railway work with the Illinois Central in June of that year. He has since been consecutively rodman on construction work, assistant engineer in charge of grade reduction and double-track work on northern and southern lines and roadmaster on the Chicago and Louisville divisions. In January, 1907, he was made assistant engineer of bridges in charge of Grand Crossing track elevation work and all outside construction work in the bridge department, from which position he has now been promoted.

Kenneth H. Hanger has been appointed chief engineer of the Chicago, Rock Island & Gulf, with office at Fort Worth, Tex., succeeding A. B. Warner, assigned to other duties.

With the Manufacturers

Chain.

Conveyor chain and steel ice chain, for use at natural ice houses, assembled in any lengths required and in width to properly fit over sprockets of the following sizes: Size of steel, 1½x7/16 in.; pitch, 6-in.; diameter of pin or rivet, ⅝ or 9/16 in.. Size of steel, 1½x⅜ in.; pitch, 6-in.; diameter of pin or rivet, ⅝ or



9/16 in. Size of steel, 1½x5/16 in.; pitch, 6-in.; diameter of pin or rivet, ⅝ or 9/16 in.; is made from first quality mild steel by the Jones Positive Nut Lock Co., of Chicago, Ill. They claim to be very particular about the quality of material used. The pins are not a soft black rivet, but are cold rolled material without scale and therefore, do not work loose and permit too much lateral swing after the chain has been in use for a short time.

They say that much of their chain is used in artificial ice plants, where it comes in contact with brine and gives excellent satisfaction. They rivet the chain in such a manner as to prevent, as far as possible, the liquid from getting into the joint, giving exceptionally good wearing qualities. The chain is illustrated herewith.

Sherardizing.

Sherardizing has been described as a process of dry galvanizing, and although in some respects it differs both from the electric and hot-dipping systems of galvanizing, it practically fulfills the same object of covering iron, steel and other articles with a coating of zinc in order to ren-

der them rust-proof. Zinc dust, the sweeping of the flues of spelter or zinc furnaces, produced by the condensation of zinc fumes, is used in this process. It is an impalpable powder, the essential components of which are metallic zinc and oxide of zinc in a fine state of sub-division, generally 80 per cent being zinc in its metallic state and 20 per cent in the state of oxide. The oxide prevents the zinc dust not only from melting but from becoming pasty, even at higher temperatures than that used, and this is one of the important factors in sherardizing.

The articles to be treated are first cleaned by pickling, more or less as is done for ordinary galvanizing, and are then placed in a drum and heated. The temperature used varies somewhat with the size and material of the articles, ranging from 500 deg. to 600 deg. F., and in some cases perhaps higher. It will be noted, however, that the temperature in no case reaches near that of the melting point of zinc, which is 788 deg. F.

The result of this treatment is that the articles are found covered with a coating of pure zinc which, so to speak, has grown upon them, first by rooting itself into the material of the article, forming a surface alloy, and then growing upwards to any required thickness, fourteen ounces and more per square foot having already been deposited as an experiment. This coating being a growth, naturally differs from the ordinary hot galvanized coating which is a homogeneous film of melted zinc wrapped round the article. The sherardized coating has, so to speak, roots, trunk, branches and leaves, and, therefore, the layers vary somewhat in texture and crystalline structure. When a very thick coating has been deposited, the top portion of it is more brittle, and although it may scale or crack off, it still leaves underneath a malleable metallic coating and below that again the surface alloy.

The alloyed part of the coating is merely skin deep, but it has the property of resisting to a great extent the action of solvents which would readily dissolve separately both the metals composing the alloy. If, for example, a sherardized screw is immersed in caustic soda, the zinc coating is in time dissolved, but when the alloy is reached the action ceases, thus leaving the screw with nothing but the alloyed portion of the coating, and yet it does not rust when exposed in the open to damp air. This is a novel feature of sherardizing, and a most important one. Although, no doubt, since the sherardizing process has become known, claims may possibly be made that an alloy of iron and zinc has been produced, it may be confidently asserted that commercially no such claim could be maintained. Its great importance consists in the fact that such an infinitesimal quantity of zinc alloyed with the iron forms, in itself, a rust-protector, so that the sherardizing process starts with a basis superior in that respect to anything else known heretofore. The ordinary flashing of tubes, either by electric or by hot dipping galvanizing, does not protect them from rust to the same extent. Moreover, if a galvanized screw is subjected to the same treatment of caustic soda mentioned above the screw immediately becomes rusty when exposed to the atmosphere.

So far, experience seems to show that the alloyed coating cannot be produced without the other deposited coatings of zinc, and these coatings accurately reproduce to shape of the article without filling up any interstices or leaving lumps of any kind. This evenness of the coating in practice means that, however thick it may be, the sharpness of screw threads, or the shape of stamped letters, is preserved, and if sufficient clearance has been given a sherardized nut will run on to a sherardized bolt as easily and smoothly as if it were not sherardized, no re-cutting of the threads being required.

Another quality of the coating is that it covers every portion of the article, owing to the fact that zinc dust, being an impalpable powder, penetrates even into the smallest corners or holes of the articles and sherardizes them without in any way clogging or filling up. Another feature of the sherardized coating is that, by reason of its consisting of pure zinc, it is easily and readily polished with an ordinary mop, by means of which the soft zinc is smoothed down, not rubbed off, into a very brilliant polished surface.

There are two features in sherardizing which ought to be pointed out because they have caused some misunderstanding. When a thick coating is deposited on an article, as has been explained, the top part is more crystalline and brittle, and when the article is roughly handled or bent, a portion is liable to crack or flake off, and many imagine that the whole of the coating has gone. This is not the case, as a malleable metallic portion and the alloyed portion are still intact. The other feature is that this top portion of the coating when exposed to rain water, and especially sea water, is partly converted into either hydroxide, or perhaps carbonate of zinc, showing a buff colored, dark yellow or whitish powder, which many have supposed to be iron rust from the article; this is not the case, and if this powder is rubbed off the more solid portion of the coating will be found intact underneath. In itself this powder is quite harmless, as it is insoluble. In fact, it may even be of some advantage, and in some cases articles are subjected to a jet of hot steam in order to produce this very film of insoluble hydroxide of zinc.

Taking the sherardized coating as a whole, there is another point to be noted in comparing it with that produced by hot galvanizing, namely, that in the case of the latter, if by means of some pinhole or otherwise, the coating were pierced down to the iron of the article, a rusting action is set up, which in time creeps between the galvanized coating and the iron, making the former peel off. In the case of the sherardized coating such a pinhole would probably only go down to the alloy and no rusting action would take place, but even if it went deeper still there would be no possibility of creeping.

The effect of the process upon steel ought to be readily understood. By the gradual heating up and then gradual cooling down, which is caused by the fact that zinc dust is a bad conductor of heat, and that therefore no sudden high temperature can be produced, the articles, while being sherardized, are at the same time subjected to a process of annealing as contrasted to the sudden plunge of an article into molten zinc and then sudden cooling. Thus, working on a large commercial scale, mild steel is, if anything, improved by sherardizing. In the case of highly tempered, thin, or case-hardened steel, the soft annealing would naturally tend to soften the steel, but in some cases, by sherardizing on a small scale and with extra care, even this has been avoided. The rotting of articles by hot galvanizing is caused, no doubt, by the uneven stress to which the structure of the metal is exposed by dipping, but in sherardizing the slight stress there may be is so evenly and gradually distributed throughout the article that no rotting takes place, even in the case where, for example, the temper of a particularly hard steel has been lowered.

With regard to the cost and economy of the process, little need be said to anybody acquainted with the electric and hot dipping systems of galvanizing. From the short description of what the process is, it will be seen that the whole plant is a most inexpensive one and suffers very little from wear and tear or deterioration. The amount of heat used is much less. The quantity of zinc required to coat an article is also much less, not only because a much thinner coating suffices as a rust-protector, but also because there is much less loss of zinc as compared with hot galvanizing in the lumps and unevenness of the coating, and in the waste caused

by the formation of zinc dross and ashes in the melting pots.

As compared with the electric galvanizing, in addition to the points mentioned, there is the high cost of the electric power required. The economy of handling is also very great in the case of suitable articles, which are merely shoveled into the receptacle and afterwards automatically sifted out from the zinc dust.

On account of the sherardizing process having to be carried out in closed receptacles, the range of articles more suitable for it varies from that of ordinary galvanizing; for example, there is no difficulty in sherardizing a watch screw, which could not be galvanized at all by any other method, and there would be some difficulty in sherardizing a large tank. Again, the problem of sherardizing roofing sheets, fencing and telegraph wire is merely a question of the designing of suitable plants in order to give to these articles the advantages of the sherardized coating. The future applications and developments of the process are bound to be wide and important, but, as at present carried out commercially, it is evident that the more suitable articles for treatment are: screws, bolts and nuts, chains, pipe fittings, castings, nails and so on, up to articles which can be readily put into closed receptacles, the largest of which so far used are drums 11 ft. long by 2 ft. diameter, outside measurements. The sherardizing of longer lengths of pipes and tubes, which can be readily done both inside and outside, thus offering a great advantage over ordinary galvanizing, would only require longer drums and ovens.

Speaking generally, sherardizing resolves itself into the following simple operations and conditions:

The articles to be treated are in the first place cleaned, that is to say, all scale and rust, as also all tar, pitch or paint, is removed by mechanical or chemical means.

The cleaned articles are then placed in iron drums or other receptacles, according to class of goods being treated.

Along with the articles a quantity of ordinary commercial zinc dust is intimately mixed.

The drum, having been filled with goods and dust, is closed up by means of a suitable door in a more or less air-tight manner.

The drum is now put into a furnace, preferably a gas furnace, and is then heated to a temperature of from 500 deg. to 600 deg. F. The drum is removed from the furnace and allowed to cool. The thickness of the coating depends on the temperature and the length of time the articles remain in the furnace.

Mechanical means should be arranged to enable the drum to be revolved very slowly or left at rest as desired.

After having been so heated for the required time the drum is withdrawn from the furnace, and allowed to cool down or artificially cooled by fans, another one taking its place. When cool enough to handle, the drum is opened and its contents emptied into a sieve, which may be either stationary or revolving.

The zinc dust falling through the sieve is carried up by a bucket elevator and emptied into a reservoir hopper on which is fixed a shoot or valve for filling the drums. The articles which have been separated out on the sieves are now finished and done with, needing no further treatment.

Material treated by this process has stood five years' test in actual service under most trying conditions. It has proved satisfactory to the British Admiralty and to the Colonial government of the Gold Coast, where conditions are such that hitherto gun metal and brass were the only commercial metals which would withstand corrosion. It has proved a much more effective coating than any other form of galvanizing in use along the Persian Gulf, and also in general use throughout the British Isles.

Chains treated with this process have remained in sea water for nine months continuously without showing any signs of corrosion.

The product has been tested chemically in a number of instances in comparison with articles treated by the hot or electric processes, in each instance showing a marked superiority over the old methods. The test used for a standard by the American Telephone & Telegraph Company, namely, the immersion for one minute in a solution of copper sulphate, specific gravity 1.185, at 70 deg. F., the articles being immersed in water and wiped dry after each dip. The test required by large consumers of galvanized material is four dips. In every test, sherardized material, coated with one ounce per superficial foot, passed through ten or more dips without breaking down.

The United States Sherardizing Co., of New Castle, Pa., to whom we are indebted for the above information, is the sole owner of the patents covering the process. This company will sherardize articles to order or will license others to carry out the process.

Fairbanks, Morse & Co., of Chicago, Ill., have issued a new catalogue, No. 113, which describes their 1910 line of two-cycle marine engines. This catalogue is well gotten up and illustrated with many fine halftones, printed on a high grade enamel paper. For 1910 they are offering two types of two-cycle marine engines, types "E" and "G." The type "G" takes the place of their 1909 type "F" and over which it is an improvement. It is built in sizes from 6 to 45 h. p., is made in one, two, three, four and six cylinders and embodies among other improvements an "auto control" which makes it particularly adaptable to boats where the engine is located forward and controlled from the cockpit. The type "E" engine, 3½ h. p. and 7 h. p. single and double cylinder, is practically the same as their 1909 model, except that a few changes have been made which add to its appearance and efficiency. High finish, accessibility, easy starting, high grade material and workmanship and efficient oiling system are some of the strong points of this line of two-cycle marine engines. Four-cycle heavy-duty Fairbanks-Morse marine engines are fully described and illustrated in catalogue No. 112B. These engines are already well known for their reliability and service. They are built in sizes from 20 to 100 h. p. with two, three and four cylinders.

Headlight Oil.

The Galena Signal Oil Co. is introducing a new oil for locomotive headlights. For some time there has been a general demand for a headlight that would produce a better light than the present oil lamp in general use. The Galena Signal Oil Co. has produced an oil that they claim meets the requirements in every respect. This oil is known as "Galena Railway Safety" oil.

Recent government tests made at Washington by the Bureau of Standards shows that this oil will produce a minimum of 1,800 candle-power in headlights of ordinary contruction, and with a headlight with 16-in. optical lens, of no greater first cost than ordinary reflectors and costing much less to maintain, a minimum of 2,400 candle-power. The makers say that exhaustive service tests on a large railway have proved its suitability to the purpose for which it was produced. Its high fire test (180° F.) enables it to withstand the great heat generated by headlight burners without becoming gaseous, a condition developing with inferior oils and resulting in the consumption of much more oil than is necessary, its high specific gravity (48° B.) enables it to feed freely through any wick.

The use of this oil is said to insure immunity from smoked chimneys, damaged reflectors and burning up of headlights, and to reduce to a great extent the labor necessary in caring for the apparatus.

"Advertising does not jerk; it pulls. It begins very gently at first, but the pull is steady. It increases day by day and year by year until it exerts an irresistible power."—John Wanamaker.

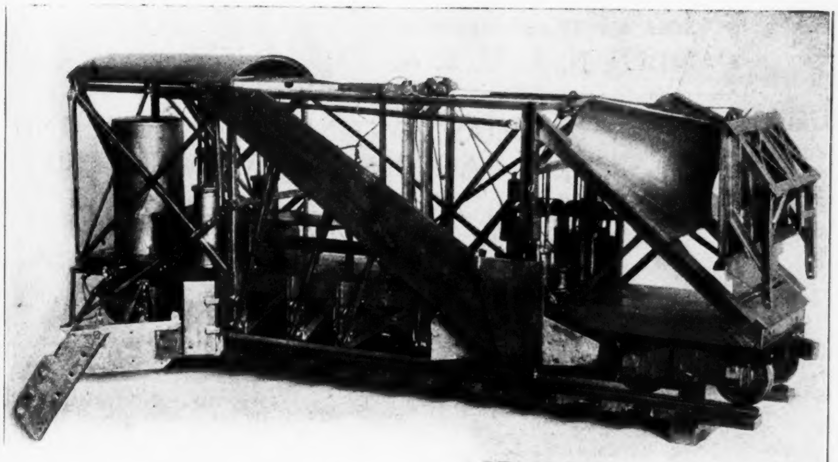
WATCH

for the October and November Issues of Railway Engineering and Maintenance of Way

COVERING

the Railway Signal Association Convention at Richmond, Va., October 11, and the Bridge and Building Association Convention at Fort Worth, Texas, October 18.

THE MANN NO. 3 SPREADER, BANK SHAPER, BANK BUILDER, BALLAST SPREADER, GRADE ELEVATOR, DITCHER, FOLDING SNOW PLOW AND FLANGER



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There are other machines, but they are not competitors with this one in ease of operation, strength, range of work or durability; not a back shop pet, but built for hard knocks.

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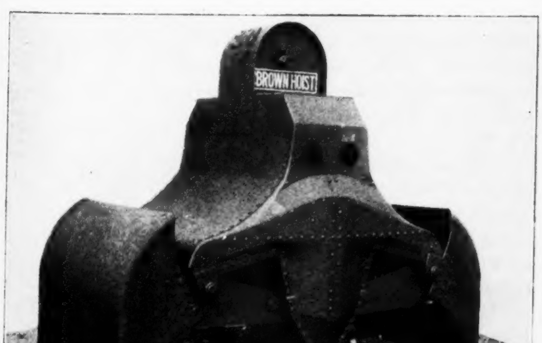

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